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ELECTRONICS AND ELECTRICAL ENGINEERING

No. 61

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16 April 1980

**USSR REPORT
ELECTRONICS AND ELECTRICAL ENGINEERING**

No. 61

This serial publication contains articles, abstracts of articles and news items from USSR scientific and technical journals on the specific subjects reflected in the table of contents.

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CONTENTS	PAGE
AMPLIFIERS.....	1
Effect of Parameter Variance in Matching Circuits and in Active Stages on the Performance of Balanced Amplifiers Built With Hybrid Circuit Integration.....	1
Instability of Amplitude Characteristics of Reflex Regenerative Amplifiers.....	2
ANTENNAS.....	4
Interlocking of Self-Excited Oscillators Operating With Coupled Radiating Elements.....	4
Radiotechnical Aspects of the Problem of Reception of Gravitational Waves.....	5
Directional Characteristics of a V-Antenna.....	5
CERTAIN ASPECTS OF COMPUTERS; CONTROL, AUTOMATION, TELEMECHANICS AND MACHINE DESIGNING.....	7
Hierarchical Procedure for Laying Out the Components of Radioelectronic Devices in Smallest Groups.....	7

CONTENTS (Continued)	Page
CERTAIN ASPECTS OF PHOTOGRAPHY, MOTION PICTURES AND TELEVISION.....	8
Discrete and Continuous Linear Filtering of a Steady Video Pulse Level.....	8
COMMUNICATIONS, COMMUNICATION EQUIPMENT, NETWORKS, RADIOPHYSICS, DATA TRANSMISSION AND PROCESSING.....	9
Reception of a Discontinuous Radio Signal Against a Background of White Noise.....	9
Estimate of Effectiveness of the Quick Method of Direct Computation of a Cyclic Convolution and Correlation.....	10
A Method of Estimating the Average Power of a Random Process With a Nakagami Probability Distribution.....	11
A Method of Discriminating Between Random Signals With Uniform Distribution of Instantaneous Amplitudes.....	12
Discrete Signals Based on Walsh Functions for a Multichannel Data Transmission System.....	12
Statistical Characteristics of a Phase Detector With Amplitude Limitation With a Random Signal-to-Noise Ratio.....	14
An Analytical Expression for the Spectrum of Walsh Functions.....	15
Use of Walsh Functions for Data Transmission Over Channels With Short Interruptions.....	16
COMPONENTS AND CIRCUIT ELEMENTS, INCLUDING WAVEGUIDES, CAVITY RESONATORS AND FILTERS.....	17
Intertype Coupling of Oscillations in a Cylinder With One and Two Longitudinal Slits.....	17
Problem of the Ambiguous Section of the Dispersion Characteristic of a Round Two-Layer Waveguide.....	18

CONTENTS (Continued)	Page
Input Impedance of Ferrite Delay Lines Under Conditions of Nonlinear Ferromagnetic Resonance.....	19
Simulation on a Digital Computer of a Nonlinear Tracking Filter During Measurement of Poisson Processes.....	21
Electronic Commutators of Analog Signals.....	21
Radiation Losses Due to a Coaxial Disjunction Between Two Dielectric stripline Waveguides.....	22
CONVERTERS, INVERTERS, TRANSDUCERS.....	23
Computer Study of Varactor Frequency Multipliers Taking into Account Recombination and Hysteresis Losses.....	23
Micropower Inverters Built with MOS-Transistors.....	24
Theoretical and Practical Developments in Integral Magnetic Heads.....	25
CYROGENICS AND SUPERCONDUCTIVITY.....	26
Experimental Investigation of Josephson Junctions with a Semiconductor Barrier and of Superconductor-Semiconductor Contacts.....	26
ELECTROACOUSTICS.....	28
Amplitude and Phase Modulation of Surface Acoustic Waves in a Layered LiNbO_3 -CdSe Structure.....	28
ELECTROMAGNETIC WAVE PROPAGATION; IONOSPHERE; TROPOSPHERE; ELECTRODYNAMICS.....	30
Fields in Tapered Multimode Waveguides and Natural Vibrations of Open Cavities.....	30
Theory of Waves in Open Gradient Fiber Light Guides.....	31
Electromagnetic Waves in Gradient Film Waveguides.....	32
Oscillations and Waves in Ladder Networks of Six-Terminal Networks Discretely Coupled with an Electron Stream.....	33

CONTENTS (Continued)	Page
Modeling of Dynamic Processes in Intense Relativistic Curvilinear Electron Streams.....	35
GENERAL CIRCUIT THEORY AND INFORMATION.....	37
Models of Digital Phase-Locked Systems.....	37
Design of a Mixer with External Bias.....	38
INSTRUMENTS, MEASURING DEVICES AND TESTERS; METHODS OF MEASURING.....	39
An Algorithm of Processing Radiotechnical Measurement Data.....	39
MICROELECTRONICS (INCLUDING MICROCIRCUITS, INTEGRATED CIRCUITS, LOGIC CIRCUITS, MICROSENSORS).....	40
Operating Modes of Integrated-Circuit Voltage Stabilizers.....	40
OPTOELECTRONICS, QUASI-OPTICAL DEVICES.....	41
Optical Correlator of Complex Phase-Manipulated Signals.....	41
RADARS, RADIO NAVIGATION AIDS, DIRECTION FINDING, GYROS.....	43
Application of Stochastic Approximation Methods to Problems in Finding the Direction of Sources of Random Fields with Unknown Parameters.....	43
Detection of Simple and Complex Signals Appearing with Reverberation Interference.....	44
Estimate of Signal Amplitude and Angular Coordinates of the Target in Adaptive Sequential Detection.....	45
SEMICONDUCTORS AND DIELECTRICS; CRYSTALS IN GENERAL.....	46
Thermal Domains in Semiconductors.....	46
Auger Recombination h-h-e in Silicon.....	46
Development of Convective Instability of Recombination Waves.....	47

CONTENTS (Continued)	Page
Anisotropic Size Effect Associated with Spin Polarization in a Semiconductor.....	47
Cathodoluminescence of Undoped Gallium Nitride.....	48
Hall Mobility in the Impurity Zone of p-Type Gallium Arsenide.....	49
Practically Attainable Spatial Frequency in Hologram Recording by the Method of Light-Sensitive Etching of Semiconductors.....	49
Activation Energy of Hopping Conductor in Weakly Doped Semiconductors.....	50
Efficiency of Electroluminescence in P-N Junctions of Gallium Arsenide Doped with Silicon.....	51
n-Si-p-GaSe Heterojunctions.....	52
Thermal Quenching of Luminescence in Glassy Chalcogenide Semiconductors.....	53
Submillimeter Photoconduction in n-InSb at 4.2-77 K Temperatures.....	54
Strong Franck-Condon Shift of a Deep Center in GaAs $\langle 0 \rangle$	54
Theory of the Magnetodiode.....	55
Nature of the Current Magnetosensitivity of 2-Collection Planar Magnetotransistors.....	56

USSR

UDC 621.375.049.77

EFFECT OF PARAMETER VARIANCE IN MATCHING CIRCUITS AND IN ACTIVE STAGES ON THE PERFORMANCE OF BALANCED AMPLIFIERS BUILT WITH HYBRID CIRCUIT INTEGRATION

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 90-93 manuscript received 25 Feb 79

PETROV, G. V.

[Abstract] Balanced amplifiers built with hybrid circuit integration of microstriplines for microwave equipment have better performance indicators, namely a less nonlinear phase-frequency characteristic and a wider dynamic range, than single amplifiers. A balanced amplifier consists of two single amplifier branches in parallel between two resistively loaded directional couplers. Each amplifier branch consists of transistor stages between a matching circuit at the input end and a matching circuit at the output end. From the standpoint of designing such a balanced amplifier, the effect of variance of components on the overall performance is analyzed here on the basis of catalog and test data. The parameters of active elements in the transistor stages and the effect of their variance are evaluated in terms of coefficients of the scattering matrix. The parameters of passive elements in the matching circuits and the effect of their variance are evaluated according to the mathematical theory of sensitivity. The critical performance parameters of an amplifier are its power gain, noise factor, input and output standing-wave ratios, and phase of its transfer function. An analysis of numerical data for a device operating with typical components in the 2-3 GHz frequency band indicates that a balanced amplifier requires trimming, preferably in the matching circuits. Components of the matching circuits are most sensitive to amplifier performance requirements, while the phase-frequency characteristic of a balanced amplifier is found to be least sensitive to variance of transistor parameters. Figures 4; tables 4; references: 6 Russian.

[156-2415]

INSTABILITY OF AMPLITUDE CHARACTERISTICS OF REFLEX REGENERATIVE AMPLIFIERS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2370-2373 manuscript received 26 Apr 78

TEKSHEV, V. B.

[Abstract] The sensitivity of the operating characteristics of regenerative amplifiers to the influence of destabilizing factors is greater than that of other microwave components in a radio receiving channel. A study is made here of the instability of the characteristics of regenerative amplifiers in the strong signal region. On the basis of a description of the matching circuit of a reflex regenerative amplifier connected between a circulator with conductance G_{ts} and an active nonlinear conductance of $G_{ne}(U)$, where U is the amplitude of the sinusoidal voltage of the signal in the terminals of the nonlinear element (NE), where this nonlinear conductance is normalized by scattering matrix [S], with the admittance in the input and output equaling respectively G_{ts} and $|G_{ne}(0)|$, the regenerative amplifier is represented by the system of equations: $[b] = [S][a]$ and $F(a_2, b_2, k_1, \dots, k_n) = 0$, where $[a]$ and $[b]$ represent respectively matrices of the complex amplitudes of the incident and reflected waves, subscript "1" refers to the input of the matching circuit at the circulator end, subscript "2" to the output at the nonlinear element end, and the second equation describes the properties of a nonlinear element with certain unknown parameters k_1, \dots, k_n . The instability of the voltage transmission coefficient with regard to a change in element parameter x is characterized by the amount of sensitivity, taking into account its dependence on the power of the signal in the regenerative amplifier's input. An equation for instability is derived in which no restrictions are imposed on the type of matching circuit. For the purpose of practical utilization of this equation, two cases are discussed: 1) When altered parameter x characterizes the properties of the nonlinear element, and 2) when x is a parameter of an element of the matching circuit. Regarded as most unstable are the parameters of an active nonlinear element under the influence of destabilizing factors. Equations are obtained for the sensitivity of the transmission coefficient to a change in the low-signal conductance of the nonlinear element for two types of oscillating characteristics. An equation is found for calculating the sensitivity of the characteristics of a regenerative amplifier to a change in parameters of elements of the matching circuit. Equations are derived which determine in parametric form the sensitivity of the characteristics of a regenerative amplifier operating in the strong signal region to a change in any element of the amplifier. Particular equations are derived for a reactive matching circuit, which is most interesting

from the practical standpoint. The results are given of a calculation for a regenerative amplifier with a low-signal transmission coefficient of 15 dB, with matching circuits with specific parameters. The procedure suggested for analyzing the sensitivity of the characteristics of a regenerative amplifier over a broad dynamic range of the signal makes it possible to determine the parameters of a regenerative amplifier matching circuit which is optimal with respect to specific characteristics, as well as to determine the permissible deviation in parameters of elements in keeping with the predetermined instability of amplitude characteristics.

Figures 3; references: 2 Russian.

[97-8831]

USSR

UDC 621.373.12

INTERLOCKING OF SELF-EXCITED OSCILLATORS OPERATING WITH COUPLED RADIATING ELEMENTS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2254-2261 manuscript received 14 Jul 78

DVORNIKOV, A. A., UTKIN, G. M. and CHUKOV, A. M.

[Abstract] The results are given of an investigation of very simple self-oscillating active phased antenna arrays in which for the purpose of phasing is employed the intercoupling of the radiating elements on which the self-excited oscillators act directly. A self-oscillating active phased antenna array is based on the ability to synchronize and thus to phase the self-oscillating modules of the system in one way of another. The employment of the principle described here makes it possible considerably to simplify the design of these arrays, since it is possible to eliminate an additional synchronization channel network. The analysis concentrates on systems of single-loop self-excited oscillators which are interlocked at the fundamental tone. In these systems overall intercoupling takes place through the total field of radiation of the radiating elements. Abbreviated equations are derived for a system of n identical single-loop self-excited oscillators with a slight frequency difference between one another. It is assumed that each self-excited oscillator is coupled with a radiating element through a coupling capacitor whose capacitance is substantially lower than the capacitance of the self-excited oscillator's resonator. It is also assumed that all radiating elements are identical and that their resonance properties are considerably worse than those of the circuits of the self-excited oscillators. As a result, it is possible to write abbreviated equations for the slowly varying amplitude, U_k , and phase, ϕ_k , of the voltage, u_k , of the k -th self-excited oscillator. These abbreviated equations make it possible to study all possible steady-state modes of the system and the conditions for their stability. A block diagram is given of the system discussed, as well as a circuit diagram of an individual self-excited oscillator. Discussed in detail are the case of two and of three self-excited oscillators. The stability of modes is investigated in terms of the relative distance between infinitely thin half-wave dipoles. It is shown that ranges of distances exist in which both the in-phase and out-of-phase mode can be stable. A graphic illustration is given of the dependence of the power radiated by the system on the relative frequency difference of self-excited oscillators. Directivity diagrams are given for a system of two radiating self-excited oscillators and for a system of two active and one passive radiating elements. The region of stability is shown for the in-phase operating mode of a system of three radiating self-excited oscillators. Figures 8; references 10: 9 Russian; 1 Western.

[97-8831]

USSR

UDC 621.391.82:621.3.029.4

RADIOTECHNICAL ASPECTS OF THE PROBLEM OF RECEPTION OF GRAVITATIONAL WAVES

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 6-12 manuscript
received 4 Jan 79

GERTSENSHTEYN, M. YE. and LEVINSON, F. A.

[Abstract] The problem of detecting gravitational waves of cosmic origin with various kinds of massive mechanical oscillator antennas is analyzed in radiotechnical terms. Accordingly, the performance of such an oscillator is described by the Einstein equivalent of the Maxwell electromagnetic field equations for a weak gravitational field and on the basis of an equivalent electrical circuit diagram. The receiver is assumed to include first a parametric 2- or 3-frequency converter, a capacitive transducer or a laser interferometer being typical examples of the latter kind, and then a system for recording the electrical oscillations. The receiver must be highly sensitive in the low-frequency range and have adequate noise suppression. Noise suppression by self-adaptive compensation, using correlational feedback with an auxiliary reference channel along the main channel, is preferable to antiseismic filters and shielding from industrial interference. Such a system also facilitates subsequent signal processing much more expediently than a conventional rejection filter would. The requirements a reference oscillator must satisfy, with regard to phase stability, are furthermore shown to be quite realistic. Figures 4; references 50: 32 Russian; 18 Western.

[156-2415]

USSR

UDC 621.396.677.832

DIRECTIONAL CHARACTERISTICS OF A V-ANTENNA

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 72-75 manuscript
received 13 Jul 79

SALAH, A. K., Republic of Iraq

[Abstract] A V-antenna is considered and the dependence of its radiation pattern in various planes on the reflector dimensions is analyzed. The two reflector plates of height h and width L are assumed to form a 90° angle, with the radiator in the form of a symmetric vibrator of height $2l_0$ located inside in the bisecting plane parallel to and at a distance b from the edge of the dihedral angle. The directional characteristics of such an antenna are calculated according to the geometrical theory

of diffraction, with the radiator replaced by an array of elementary electric oscillators. Only direct primary rays and 16 groups of rays variously reflected by the plates or diffracted by their free edges significantly contribute to the electric field of the antenna. Calculations disregarding all other rays show that the radiation pattern in the far field in any plane intersecting the common edge of both reflector plates depends on the angle this plane forms with this edge as well as on the width L of the plates. Furthermore, as distance b from the radiator to that edge increases from smaller than a quarter wavelength to larger than a half wavelength, a change in plate height h first does not affect but then gradually more appreciably affects the radiation pattern. The accuracy of this method was checked against calculations for the radiation pattern in a plane normal to the common edge of the reflector plates. Figures 5; references 8: 5 Russian; 3 Western.
[156-2415]

Certain Aspects of Computers; Control, Automation,
Telemechanics and Machine Designing

USSR

UDC 621.3.049.77.001.2

HIERARCHICAL PROCEDURE FOR LAYING OUT THE COMPONENTS OF RADIODEVICE
IN SMALLEST GROUPS

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 25-28 manuscript
received 5 Jul 79

TOPOL'SKIY, N. G. and NOSKOV, V. P.

[Abstract] Computer-aided engineering design of automation systems involves packaging and layout of the components as well as routing of the connections. The optimum layout on a large-scale integration substrate is one with the minimum total length of interconnections. Here a method is shown of finding the optimum layout through limited sorting of possible variants. It is based on the "smallest groups of components" principle of subassembly and is essentially hierarchical. A theorem is proved analytically, with the aid of several special definitions, which renders this method valid in the case of linear layout but which can also be extended to two-dimensional layout on a board and three-dimensional layout. The method is demonstrated on directional sorting which is not complete but only seeks the smallest groups of $(i-1)$ th rank in the i -th layout step. Figures 4; references 3: 2 Russian; 1 Western.
[156-2415]

Certain Aspects of Photography, Motion Pictures
and Television

USSR

UDC 621.397.2

DISCRETE AND CONTINUOUS LINEAR FILTERING OF A STEADY VIDEO PULSE LEVEL

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2278-2289 manuscript received 29 Dec 78

DVORKOVICH, V. P.

[Abstract] The optimal filtering of a steady video pulse level is discussed, a problem which arises in measuring the range of video pulses when steady values of these pulses are transmitted in the presence of fluctuation noise. It is assumed that at the peak of a video pulse there is an interval of length T in which the level of the signal is steady. The fluctuation noise combined additively with the video pulse does not have a steady component. During interval $0 \leq t \leq T$ the process can be represented in the form $\eta(t) = C + \xi(t)$, where $C = m_1\{\eta(t)\}$ is the mathematical expectation of the process characterizing the level of the video pulse in the processing region, and $M_2\{\eta(t)\} = M_2\{\xi(t)\} = m_2\{\xi(t)\} = \sigma_k^2$ and $m_1\{\xi(t)\} = 0$ are respectively the variance and mathematical expectation of the fluctuation noise, $\xi(t)$. An equation is presented for the noise's variance in a class of linear transformations in digital averaging of correlated discrete readings with a fixed amount of sampling. The conditions are arrived at for the optimal discrete linear filtering of a signal during interval T . The conditions are arrived at for the optimal continuous linear filtering of a steady video pulse level during interval T . The key parameter involved here is μ , characterizing the reduction in the noise's variance as a result of continuous linear filtering. Equations are derived which characterize the parameters of optimal discrete and continuous converters for noise with differing spectral power density. Structural diagrams are presented for designing an optimal filter for different cases of the noise's spectral power density. An expression is arrived at for the amount of the optimal reduction in the noise's variance in discrete conversion of the signal. An equation is given for determining the equivalent frequency characteristic of an optimal continuous converter. Curves are presented, illustrating the dependence of optimal reduction of the noise's variance on the length of the signal processing interval with different values of the noise's spectral power density. It is shown that the value of μ can be lowered in proportion to how great a part of the noise's spectral power is concentrated in the low-frequency region. With a noise spectrum of limited range, its variance can be reduced considerably by the optimal summation of even derivatives of the noise. It is demonstrated that for the purpose of improving the accuracy of determining the range of video pulses in the presence of fluctuation noise with a limited spectrum it is necessary to employ special signals having in the processing region the maximum possible number of even derivatives equal to zero. Equations are derived which characterize the parameters of linear conversion by means of the optimal summation of even derivatives of the noise for cases when its spectrum is uniform and of the delta type. Figures 5; references: 6

Russian.

[97-8831]

USSR

UDC 537.86:519

RECEPTION OF A DISCONTINUOUS RADIO SIGNAL AGAINST A BACKGROUND OF WHITE NOISE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2226-2234 manuscript received 15 Nov 77

TRIFONOV, A. P.

[Abstract] The method of maximum plausibility is often employed for the purpose of detecting radio signals containing unknown parameters and for estimating these parameters, and the equipment implementing this method is called a maximum-plausibility receiver. Here approximate expressions are found for the characteristics of a maximum-plausibility receiver in the incoherent reception of a discontinuous radio signal with an unknown non-energy parameter. The output signal of a maximum-plausibility receiver is analyzed on the basis of the random process in the form of Gaussian white noise entering the receiver's input. An equation is derived which defines the asymptotic behavior of the distribution function of the absolute maximum of the noise in the output of a maximum-plausibility receiver. A theoretical discussion is given of detection of the radio signal. On the assumption that a useful signal is present in the receiver's output, a determination is made of the probability of absence of a signal. The noise in the output of a maximum-plausibility receiver is a steady-state process. The general equations obtained are made specific for the detection of a narrowband radio pulse with a square envelope and an unknown time state. A direct comparison is made of the probability of error in the detection of a signal with a known and unknown time state. This makes it possible to estimate the influence of the a priori time interval T_0 , where it is assumed that the unknown time state, T , of the signal has a value within the range of $[-T_0/2; T_0/2]$, and of the length of the signal, Δ , and of normalized threshold μ , on the effectiveness of detection. It is demonstrated that the accuracy of the equations arrived at increases with an increase in the signal-to-noise ratio and the a priori interval for determination of the unknown parameter. Estimates are made of the probability of signal omission and of false alarm. A discussion is given of the characteristics of a maximum-plausibility receiver when an estimate is made of unknown parameter ℓ_0 of the signal, where during time interval $[0; T]$ enters the receiver a realization of random process $x(t) = n(t)$, or $x(t) = s(t, \ell_0, \phi_0) + n(t)$, where $n(t)$ represents the realization of Gaussian white noise

with a linear spectral density of n_0 , and $s(t, \ell_0, \phi_0) = F(t, \ell_0) \cos [\omega_0 t + \Psi(t, \ell_0) - \phi_0]$ is a narrow-band radio signal with an unknown initial phase, ϕ_0 , and non-energy parameter ℓ_0 . Asymptotically precise expressions are found for the characteristics of the detection of a discontinuous signal and for estimating its unknown parameter by the maximum plausibility method. References 15: 14 Russian; 1 Western. [97-8831]

USSR

UDC 621.391.2

ESTIMATE OF EFFECTIVENESS OF THE QUICK METHOD OF DIRECT COMPUTATION OF A CYCLIC CONVOLUTION AND CORRELATION

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2212-2221 manuscript received 29 Oct 78

MAZURKOV, M. I. and SVERDLIK, M. B.

[Abstract] Different methods of quick transformation are employed in order to reduce the number of operations involved in computing correlations, such as the correlation of two number sequences represented in vector form. The key factor in these transformations is the periodicity of the kernel of the transformation. The possibilities of constructing quick method for directly computing a convolution and correlation have been insufficiently investigated and estimates of their computation efficiency are lacking. In an earlier study (1969) a quick convolution algorithm was suggested for the purpose of detecting periodic pulse trains. The essence of this algorithm was the elimination of redundant operations occasioned by the periodicity of detected trains. Here an estimate is made of the computation efficiency of a quick method of directly computing a cyclic convolution and correlation in which for the purpose of eliminating redundant operations use is made of individual structural properties of sequences being correlated or convoluted. Number sequences are discussed which are characteristic of manipulated signals whose parameters change discretely and take on values from a finite set of order p , the base of the sequence, of different states. The unified approach is discussed, of designing various methods of quick computation in which a unidimensional array of numbers is transformed into a two-dimensional one for cases when the length of the number sequence is expandable. It is demonstrated that computing efficiency increases with an increase in N , the length of the sequence, and the degree of expandability of N . The conditions for the existence of computational redundancy are found and the structure of this redundancy is revealed, and a regular method is suggested for eliminating redundancy. A determination is made of the bottom limit of the computation efficiency.

of the method described. The fact that the efficiency of the method increases with an increase in N and the degree of its expandability bears a similarity to the rapid Fourier transform method used in computing a discrete Fourier transform. The estimates obtained prove that the quick method of directly computing a correlation or cyclic convolution is sufficiently efficient. A distinctive feature of the method is the fact that the efficiency of multiplication is always higher than that of addition. References 8: 7 Russian; 1 Western.
[97-8831]

USSR

UDC 621.391.2

A METHOD OF ESTIMATING THE AVERAGE POWER OF A RANDOM PROCESS WITH A NAKAGAMI PROBABILITY DISTRIBUTION

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 64-67 manuscript received after completion, 1 Mar 79

IVANKIN, P. A. and LEBEDINSKIY, YE. V.

[Abstract] A method of estimating the average power of a random process with a Nakagami m -distribution of probabilities is shown which does not require squaring and subsequent summation. This method utilizes the properties of distribution quantiles, a χ_{α} -quantile of order α being related to the χ^2 -distribution. Calculations show that the 0.75 quantile is almost independent of parameter m ($1/2 \leq m \leq \infty$) and, therefore, should be used as estimator of the average power when the value of m is not a priori known. The error of measurements will then not exceed 0.1, while in the case of an a priori known value of parameter m this estimator is almost as accurate as an efficient estimator. An advantage of this estimator is that it imposes less severe requirements on the measuring instrument with respect to linearity and dynamic range. The method can be further refined for the case of a small sample. Figures 2; references 4: 2 Russian; 2 Western.
[156-2415]

USSR

UDC 621.391

A METHOD OF DISCRIMINATING BETWEEN RANDOM SIGNALS WITH UNIFORM DISTRIBUTIONS OF INSTANTANEOUS AMPLITUDES

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 67-69 manuscript received after completion, 9 Apr 79

KUZNETSOV, YU. A.

[Abstract] Two signals are considered which consist of pulse trains with mutually independent amplitudes uniformly distributed over the ranges $0 - a_1$ and $0 - a_2$ respectively ($a_2 > a_1$). A discriminator is considered, furthermore, which raises their amplitudes to a power $n > 1$ with subsequent summation and compares the sum of squares with some threshold. This threshold is chosen so that the probability of it being exceeded by signal one will be low and equal to the probability of error. If it is exceeded, on the other hand, this will signify the presence of signal two. The probability of correct detection of signal two is now calculated by applying the central-limit theorem to identically distributed independent variates with a finite mean and a finite dispersion each, also assuming normal distributions of those sums. The higher the probability of the threshold being exceeded by signal two is, the more efficient will be the discriminator. Simulation tests have shown that the probability of correct discrimination increases with a higher power exponent n . Tables 2; references 2: Russian.

[156-2415]

USSR

UDC 621.391.2

DISCRETE SIGNALS BASED ON WALSH FUNCTIONS FOR A MULTICHANNEL DATA TRANSMISSION SYSTEM

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79 pp 2222-2225 manuscript received 14 Nov 78

LOSEV, V. V.

[Abstract] In an earlier study (1964) a description was given of discrete signals with a length of $N = 2^n$ characters for an n -channel data transmission system with a group signal transmission rate of $R = n/N$. A discussion is given here of signals with a higher rate for the processing of which it is feasible to employ Walsh rapid transformation algorithms. With $F = \{W_i, i = 1, N\}$ representing a set of Walsh functions, signal A is formed by a majority transformation of the values of n functions (components) of set F and their inversion, i.e., $A = \text{Maj} (b_1 W_{i1}, b_2 W_{i2}, \dots)$.

$b_n W_{in}$), where n is an odd number. $B = (b_1, b_2, \dots, b_n)$, $b_1 = 1, -1$; $I = (i_1, i_2, \dots, i_n)$. A description of a set of signals of type A then reduces to recomputation of vectors B and I , which can be regarded as information parameters of signal A. It is thus possible to transmit information by varying vectors B and I . A study is made of the possibility of transmitting data by this method by representing signal A as a functional series containing terms representing the spectral coefficients of signal A on a Walsh-Fourier basis. The transmission of information is discussed, employing the method of inverting components. Here vector I is fixed and information is transmitted by means of vector B . There exist 2^n different B vectors, so that with fixed B signal A will transmit n bits of information. The receiver then must contain n correlators whose reference signals are the components $W_{11}, W_{12}, \dots, W_{in}$. An expression is given for the probability of error per character in a received n -dimensional word. A disadvantage of this system is the relatively low transmission rate, equaling n/N . Also discussed is the transmission of information by means of the exchange of components. In the set of Walsh functions, F , are selected $n]N/n[$, where $]x[$ is the nearest number not higher than x , elements and they are broken down into n classes with $]N/n[$ functions in each class. Corresponding to each class is a binary ℓ -bit number, where $\ell = \lceil \log_2(N/n) \rceil$. Vector I is selected for one representative from each class, so that sequence A will transmit $n\ell$ bits of information. Separation of this information is accomplished by the recognition of components. A table is given of values of $n\ell$ for certain n . By this method is achieved an ℓ -fold increase in the transmission rate as compared with the first method discussed. Components are separated by a multichannel correlation receiver. Inasmuch as N is high, it is advisable to use Walsh rapid transformation algorithms and processes for practical implementation of this receiver. An expression is given for calculating the probability of error per bit. Also discussed is coding which features unequal protection of characters. This method can be used when the information transmitted by individual characters of messages is not the same value. Here set F is broken down into classes with different numbers of functions, whereby the class with the least number of terms is used for coding the most important part of the information and the class with the highest number of terms for coding the least important part of the message. The example is given of breaking down Walsh functions into classes with identical periods. This method is used in clock synchronization applications. Tables 2; references 9: 8 Russian; 1 Western.

[97-8831]

STATISTICAL CHARACTERISTICS OF A PHASE DETECTOR WITH AMPLITUDE LIMITATION
WITH A RANDOM SIGNAL-TO-NOISE RATIOMoscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2235-2243 manuscript received 5 Jul 78

YEVSIKOV, YU. A. and CHILIKIN, V. M.

[Abstract] The effect is discussed of the sum of a harmonic signal and narrow-band and steady-state normal random noise with an energy spectrum of arbitrary form on a series-connected envelope limiter and phase detector. This unit is used for amplitude limitation for the purpose of compressing the dynamic range of input oscillations in phased systems. The method of amplitude limitation is used especially in digital systems to make it possible to reduce substantially the number of elementary operations in signal processing. In analyzing the noise rejection of and in statistical modeling of systems of this sort it is necessary to determine the statistical characteristics of the envelope limiter - phase detector unit. For the majority of practical applications it is sufficient to find only the correlation function or energy spectrum of the output process, $u_d(t)$. This problem has been solved with the effect on the unit of a mixture of a harmonic signal and normal steady-state noise only for the asymptotic case of low values of the signal-to-noise ratio, q^2 . A smoothed limiter is discussed, whose characteristics vary from linear to ideal depending on the values of parameters. It is demonstrated that the problem here reduces to calculation of the correlation function of the cosine of the phase of the mixture of the harmonic signal and noise. It is emphasized that the equations arrived at are explicit and do not contain integrals and can be used with a random phase of the signal and form of the noise's energy spectrum. A theoretical analysis is made of the process at the output of the envelope limiter. Equations are derived for the mean value of process $u_d(t)$. For describing the output voltage of the phase detector, it is represented as a multiplier with the subsequent separation of low-frequency components of the spectrum. The correlation function of process $u_d(t)$ is discussed theoretically. The correlation function is found for the phase detector's output process for the case of a smoothed limiter with a random difference in the phases of the signal and reference oscillation. The results are given of a calculation of the spectral density of the output process at frequencies near zero. Curves are shown for the dependence of the normalized value of this density on the phase of the signal with different signal-to-noise ratios, calculated for a symmetric shifted noise spectrum with ideal limitation. It is demonstrated that the values of the spectral density depend substantially

on q^2 . The curves also show a strong dependence of values of the spectral density at frequencies close to zero on the phase of the signal with high signal-to-noise ratios. The phase of the signal has the strongest influence in the limiting case of high signal-to-noise ratios satisfying the condition $q^2 \gg 1/\sin^2 \phi_s$, where ϕ_s is the phase of the signal. Figures 2; references 15: 11 Russian; 4 Western.
[97-8831]

USSR

UDC 621.391.8

AN ANALYTICAL EXPRESSION FOR THE SPECTRUM OF WALSH FUNCTIONS

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 33-39 manuscript received after completion, 9 Jan 79

L'VOVICH, A. A. and KUZ'MIN, B. D.

[Abstract] A universal analytical expression is derived for the spectrum of Walsh functions regardless of their arrangement pattern. The spectral characteristics of only one subset of these functions are needed, and here those of the even subset with odd numbers of sign reversal within one half-period are used, those of the other (odd) subset following directly. A Walsh function is represented as a sequence of binary elements and the origin of coordinates is located at the center of even symmetry. The resulting expression for the amplitudes makes possible an analysis of the spectrum without prior computer simulation of these functions. As a typical example the case is considered of $k = 2^{n-2} + 1 = 65$ sign reversals within one half-period ($2k = 130$ is equivalent to $g_{2k}(q) = 1100011$ in the Gray code). Higher-order spectra can be easily calculated from already known values for lower-order spectra by the use of a recurrence formula. Figures 5; tables 1; references 7: 3 Russian; 2 East German; 2 Western.
[156-2415]

USSR

UDC 621.391.883.3

USE OF WALSH FUNCTIONS FOR DATA TRANSMISSION OVER CHANNELS WITH SHORT
INTERMISSIONS

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 39-43 manuscript
received after completion, 4 Apr 79

CHAYKO, K. I.

[Abstract] A method of coping with short intermissions in communication channels is proposed, by using Walsh functions as the data carriers. The data transmission channel includes a generator of code sequences in the form of a complete orthogonal Walsh set. Referring to the statistical characteristics of fluctuation noise and of noise caused by intermittency, the error probability in data transmission with Walsh functions is calculated for a group signal with no pulse or one pulse or two pulses affected by intermissions. Figures 4; references 2: Russian.

[156-2415]

USSR

UDC 621.372.413-434.1

INTERTYPE COUPLING OF OSCILLATIONS IN A CYLINDER WITH ONE AND TWO
LONGITUDINAL SLITS

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pp 2350-2352 manuscript received 10 Apr 78

KOSHPARENOK, V. N., MELEZHIK, P. N. and SHESTOPALOV, V. P.

[Abstract] A demonstration is given of the fact that in a round regular waveguide of radius a with the existence of one or two lengthwise slits of angular dimension 2θ strong electromagnetic coupling originates between certain types of H -waves whose internal transverse wave numbers are quite close to one another. A study is made of the origin of intertype coupling in terms of the nature of the dependence of the waveguide's transverse wave numbers, k_{\perp} , on the width of the slit, θ , represented in the form $k_{\perp} = (\nu_{mn} + x + iy)/a_2$, where ν_{mn} represents the roots of a derivative of a Bessel function of the first kind, $J_m'(\nu_{mn}) = 0$, and $(x + iy)/a$ represents the complex displacement from the transverse wave number of a regular waveguide caused by the appearance of a slit. Approximate equations are derived for determining function $f(\theta) = k_{\perp}a$, for the case of exponentially narrow slits. Curves are shown which illustrate dependence $f(\theta) = k_{\perp}a$ for H_{41}^8 modes, calculated from a strict dispersion equation for a round cylinder with one longitudinal slit and calculated with an approximate equation presented here. These curves essentially represent a Wien graph for coupling frequencies in a doubly connected system, where parameter θ alters the tuning frequency of the resonant structure. Also shown is the above-named dependence for H_{41}^8 modes. An investigation of the structure of resonance fields in a round waveguide with a longitudinal slit has indicated that near the maximum convergence of values of resonance frequencies a particular "hybridization" of both types of waves takes place. For a cylinder with two symmetrically arranged slits the $f(\theta)$ curves for H_{41}^8 and H_{12}^8 oscillations have a point of intersection representing a fundamental difference from the behavior of similar curves for a cylinder with a single slit. This demonstrates a lack of intertype coupling for these modes. In real waveguides with two slits, slight inhomogeneities on their surfaces can result in the origin of strong intertype coupling and in considerable parasitic effects. In an ideal cylinder with two symmetric slits, oscillations with the same evenness of variations in terms of the azimuthal coordinate enter into intertype coupling, e.g., H_{13}^8 and H_{32}^8 oscillations. For wide slits when the inhomogeneity is great, the condition of proximity of the natural

frequencies of the regular structure is not necessary for the origin of intertype coupling. It is demonstrated that in a round cylinder are possible both strong examples of intertype coupling and the appearance of points of convergence of natural frequencies. This fact should always be taken into account in round waveguides for the purpose of avoiding undesirable parasitic effects. The authors thank Kh. L. Garb and P. Sh. Fridberg for helpful discussion. Figures 2; references 7: Russian. [97-8831]

USSR

UDC 621.372.8.001.24

PROBLEM OF THE AMBIGUOUS SECTION OF THE DISPERSION CHARACTERISTIC OF A ROUND TWO-LAYER WAVEGUIDE

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pp 2356-2359 manuscript received 23 Jan 78

TRIFONOV, I. P., Sofia University Physics Department, People's Republic of Bulgaria

[Abstract] The practical utilization of the HE_{11} hybrid return wave in a round two-layer waveguide requires knowledge of the low-frequency limit of the ambiguous section of this wave's dispersion characteristic, as well as of the dependence of its width on the dielectric constant of the rod and the space factor of the waveguide. An analytical expression is derived here for the low-frequency limit of the ambiguous section, calculations are made of the width of this section and an analysis is made of the influence of the dielectric constant and space factor on this width. The dispersion characteristic is given for an HE_{11} wave with a dielectric constant of 50 and a space factor of 0.8, from which it is obvious that at the low-frequency end the boundary of the ambiguous section corresponds to a value of the moderating ratio at which the group velocity in the waveguide becomes equal to zero. An analytical expression is found for the low-frequency limit of the ambiguous section on the basis of an expression for the normalized group velocity when this expression equals zero. An equation is also derived for the width of the region of ambiguity. With these equations a calculation was made of the width of the ambiguous section over the range of variation of the rod's dielectric constant from 12 to 90 and of the waveguide's space factor from 0 to 1. Curves are shown, illustrating the dependence of the width of the ambiguous section on the space factor with different dielectric constants of the rod. With an increase in dielectric constant, the maximum range of ambiguity increases and shifts in the direction of higher values of the space factor. Curves are shown, illustrating the dependence on the dielectric constant of the maximum width of the ambiguous section and of the value of the space factor and moderating ratio corresponding to it. Also illustrated

are dependences of values of the moderating ratio corresponding to the low-frequency limit of the ambiguous section on the space factor with different values of the rod's dielectric constant. These curves make it possible to compute and plot the range of ambiguity in coordinates $\Delta(a/b)$ - a/b at a fixed frequency, where a/b is the space factor. The calculations performed in this study were done on an IBM-370/145 computer. The width of the region of ambiguity is determined by the equation $\Delta(\lambda/b) = \lambda_1/b - \lambda_k/b$, where λ_k/b is the critical wavelength normalized for the waveguide's radius and λ_1/b is the low-frequency limit of the region of ambiguity. The author thanks B. M. Karelbskiy for construction of a program for calculation of dispersion characteristics. Figures 4; references 6: 4 Russian; 2 Western.

[97-8831]

USSR

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INPUT IMPEDANCE OF FERRITE DELAY LINES UNDER CONDITIONS OF NONLINEAR FERROMAGNETIC RESONANCE

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BASHKOVSKIY, A. V., ZUBKOV, V. I. and TSARUKYAN, T. M.

[Abstract] A considerable disadvantage of ferrite delay lines in microwave technology is the dependence of their matching with the microwave signal channel on the level of the microwave power. This dependence is related to the parametric excitation of spin waves, i.e., to the origin of nonlinear ferromagnetic resonance. Hitherto there have been no theoretical studies on the instability of spin waves evolving in an inhomogeneous internal magnetic field of a ferrite model with inhomogeneous pumping. Given here are a description and the results of an experimental investigation of the behavior of the effective and reactive input impedance of a ferrite delay line as a function of the power of the microwave signal before and beyond the threshold of spin instability. The experiment was conducted with a measuring line employing a model of a planar ferrite delay line containing ferrite plates consisting of a single crystal of yttrium iron garnet measuring $1 \times 4 \times 10 \text{ mm}^3$ with saturation magnetization of $4\pi M_0 = 1750 \text{ Gs}$ and a resonance line width of $2\Delta H \approx 1 \text{ Oe}$. The plane of the plates coincided with crystallographic plane (110), and the 4-mm-long edge with axis $\langle 111 \rangle$. The constant external magnetic field, H_0 , was directed along the 10-mm-long edge. In order to match the ferrite plate with the microwave channel and to excite in it magnetostatic body

waves propagated along field H_0 , the plate was placed between the inductive sections, parallel to the 4-mm-long edge, of two identical low-frequency microwave band filters with a maximum flat frequency response, with a cutoff frequency of 2.4 GHz, and loaded onto a segment of a short-circuited stripline of variable length. This length was selected so that the input impedance of the matching device would be purely effective prior to the threshold for the excitation of spin instability. A curve is shown, indicating the dependence of the standing wave ratio and delay time on the magnitude of the magnetic field applied at a frequency of 2.3 GHz and a power level below the threshold, where the threshold of spin instability in the propagation of magnetostatic body waves is in the range of 0.3 to 1.0 mW. These curves characterize initial tuning of the system. Another set of curves is shown which illustrates the change in the delay line's input impedance in the excitation of magnetostatic body waves at power higher than the threshold of spin instability. No important changes were observed in this system before the threshold. Immediately beyond the threshold the effective and reactive input impedance increase, then a dip occurs, and there is an increase again. The determining factor in an increase in the standing wave ratio is an increase in the normalized reactive input impedance. Normalization was performed in terms of the wave impedance of the conducting line. With an increase in the delay time the curves for normalized effective and reactive input impedance become smoother. This is associated with the fact that with a longer path of the pulse through the plate processes of parametric excitation are successfully established. The effective part of the impedance becomes more and more unaltered with an increase in pulse length. Meanwhile, the reactive part of the impedance increases and becomes set at a level of 0.6 times the normalized reactive input impedance, remaining capacitive all the while. The general conclusion is drawn that the parametric excitation of spin waves results in an increase in the input impedance of a ferrite plate utilizing microwaves up to certain limits, after which a reduction in this magnitude begins, followed by an increase again which is determined by the change in the reactive part of the impedance. The results arrived at can be utilized for the purpose of tuning ferrite delay lines with high levels of microwave power. Some qualitative conclusions are drawn regarding the parametric excitation of spin waves in ferromagnetic models in which the constant internal magnetic field is inhomogeneous and wave pumping is also inhomogeneous. These include the fact that the effective input impedance is proportional to the imaginary part of the magnetic susceptibility, and the reactive to its real part. The dependence revealed here, of the threshold of the parametric excitation of spin waves on the pulse length, whereby the threshold is constant and does not increase with a reduction in the length of the pulse, has been encountered for the first time in the study of nonlinear phenomena. The authors are grateful to S. A. Borisov and Yu. Sh. Temirov for assistance in conducting the experiments. Figures 2; references 8: 6 Russian; 2 Western.

[97-8831]

USSR

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SIMULATION ON A DIGITAL COMPUTER OF A NONLINEAR TRACKING FILTER DURING MEASUREMENT OF POISSON PROCESSES

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 53-56 manuscript received 4 Apr 79

MART'YANOV, A. N. and TATSENKO, V. G.

[Abstract] A class of nonlinear filters is considered with which a Markov process satisfying some linear stochastic differential equation can be evaluated, according to the mean-square-error criterion, from measurements of a conditional Poisson process. The differential equations with a covariant error matrix describing a quasi-optimal estimation cannot be solved analytically and, therefore, are transformed to finite-difference equations. Thus simulation of the filter reduces to a simultaneous numerical solution of the original differential equations. This method is illustrated first in the simple case of a Markov process which has two additive components: a deterministic one and a random one. It is then extended to a process representing the integral, with respect of time, of the sum of two processes: a random one and a stationary one. Tracking becomes steady after a transient period of time which depends not only on the frequency fluctuations but also on the mean value of the intensity function characterizing the measured Poisson process. Figures 2; references 9: 5 Russian; 4 Western (2 in translation).

[156-2415]

USSR

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ELECTRONIC COMMUTATORS OF ANALOG SIGNALS

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 79-82 manuscript received 20 Mar 79

IGNATOV, A. N., MARTYUKHIN, K. V. and NIKIFOROV, V. V.

[Abstract] The structure of an electronic multichannel commutator with field-effect transistors operating as switches is described which, in the general case, has k inputs and n outputs. Such a commutator requires a total of kn switches to ensure that any input can be connected to any output. Matching the inputs to the outputs requires, furthermore, $k+n$ buffer amplifiers. Each switch is provided with an individual control circuit and its "on" indicator. A large-capacity commutator of this kind can be automatically controlled through a computer, in which case the structure must also include an appropriate interface. Each switching

channel can be built with either discrete or integrated components. A typical structure of such a channel is shown where the switching module contains a T-network with a pair of KP302B field-effect transistors in the series arms and an MP116 bipolar silicon transistor in the shunt arm, this bipolar transistor also serving as the control element. The control circuit includes also a trigger built on an AI301V tunnel diode with a resistor. The buffer amplifiers are voltage repeaters, each built on a KP103M field-effect transistor with KT315G and GT404V bipolar transistors. Decoupling capacitors between a switch and a buffer amplifier prevent switching of d.c. voltage during commutation of analog signals, but they also lower the operating speed to 2 s. In a channel built with components in a K284KN1 integrated circuit and TTL logic there is no need for these capacitors and the operating speed remains high, $3 \cdot 10^{-6}$ s, dependent on the switch characteristics only. Here an AL102V light-emitting diode serves as "on" indicator. Figures 3; tables 1: references 5: Russian. [156-2415]

USSR

UDC 621.396

RADIATION LOSSES DUE TO A COAXIAL DISJUNCTION BETWEEN TWO DIELECTRIC STRIPLINE WAVEGUIDES

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 75-76 manuscript received 30 May 79

MURMUZHEV, B. A. and POPOV, V. A.

[Abstract] A stripline waveguide is considered which consists of dielectric films on a substrate with a lower dielectric permittivity, and which has been coaxially split from another rectangular stripline, one of them being movable and the other one stationary. Radiation losses caused by such a disjunction have been calculated according to approximate expressions for single-mode optical fibers without re-reflections at both ends and with a Gaussian distribution of the fields of waveguide modes. This method of calculation avoids difficulties caused by the intricate transverse distribution of amplitudes of low-order waveguide modes E_{11}^x , E_{11}^y and the asymmetry of the dielectric space around the given stripline. The calculations are compared with experimental data pertaining to a 100 mm long stationary stripline and a movable segment of a 200 mm long stripline. The stationary stripline was coupled through a horn-strip junction to a 2-mm waveguide channel including an OV-22 tube, a p-i-n modulator, a precision attenuator and a measuring line. On the upper surface of the movable stripline segment a detector head was placed, in order to ensure an adequate decoupling. The authors thank V. V. MERIAKRI for discussion of the results. Figures 2; references 10: 8 Russian; 2 Western. [156-2415]

USSR

UDC 621.372.632.01

COMPUTER STUDY OF VARACTOR FREQUENCY MULTIPLIERS TAKING INTO ACCOUNT RECOMBINATION AND HYSTERESIS LOSSES

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2262-2270 manuscript received 20 Dec 78

GARBUZENKO, A. P., GRINBERG, G. S. and KHOTUNTSEV, YU. L.

[Abstract] The spectrum method ordinarily used in studying varactor frequency multipliers assumes the existence of only certain harmonics in the oscillation spectrum in a system. Here a study is made of a frequency doubler, tripler and quadrupler, and these devices are optimized, by the state variable method, a method of integrating differential equations describing a nonlinear system without restrictions on the form of oscillations in the system. The employment of this method makes it possible to determine energy, impedance, amplitude, amplitude-frequency and phase-frequency characteristics, the sensitivity of characteristics to a change in parameters, and also the differential parameters of the steady-state operating mode of a diode necessary for investigating the fluctuation characteristics and analyzing the stability of varactor frequency multipliers. The study takes into account all the mechanisms for losses in the diode, such as losses in the base and recombination and hysteresis losses. The study here is limited to the stage of analysis in which a calculation is made without taking into account parasitic parameters of the diode and with the existence of tap filters in the circuit which make it possible to separate a number of components in the oscillation spectrum. A model is presented of a diode which makes it possible to take into account recombination and hysteresis losses. A varactor diode is described by two sets of equations for the current, voltage and charge for the two possible states of the diode, open and closed, and by boundary conditions relating these equations at instants when the diode switches from one state to the other. These equations are somewhat modified to allow a time-dependence approach to analysis of the steady-state mode of a diode. An equivalent circuit is presented for the diode, which includes a source of current equal to the current for dissipation of the residual charge of the diode's base, a two-position switch whose positions represent the open and closed state of the diode, a constant resistance characterizing active losses in the diode related to the resistance of the base and contacts, and a nonlinear capacitor the voltage in which is equal to the voltage in the diode's depletion-layer capacitance on account of the deduction of the contact difference in potential. Experimental investigations have demonstrated that in the doubler and tripler circuits shown here at a fixed frequency it is possible to achieve a stable frequency multiplication mode with high efficiency and a low level of spurious harmonics. A solution

is given for equations of state for a varactor frequency multiplier. The algorithm involved in determination of the instants of triggering and cut-off of the diode is discussed. Values of efficiency are given for different kinds of multipliers arrived at in an earlier study (1965) and values calculated here for the circuits discussed prior to and after optimization. The Runge-Kutta method was employed to integrate the system of equations of state. Several results are discussed of the designing and optimization of varactor frequency multiplier models, whereby efficiency is considered the most important operating characteristic. Efficiency is defined here as the ratio of the power of the output harmonic of the current in the load to the maximum active power of the generator of the input signal. The problem of optimizing a varactor frequency multiplier is formulated as a problem of determining maximum efficiency in a space of specific resistance, inductance and power parameters. This problem is solved by the method of descent by coordinate with even spacing of coordinates. Each parameter is varied by 10 percent of its original value in one direction or the other in intervals of 2.5 percent. Sequences of variations of parameters in a cycle are given which result in the greatest approximation of maximum efficiency for a doubler, tripler and quadrupler. Time diagrams are given for current, voltage and charge in the base of the diode in the steady-state mode for some typical cases of optimal circuit parameters. Under optimal conditions the level of spurious harmonics in these multipliers is quite low, below 20 dB. Unlike the spectrum method, employment of the time-dependence method makes it possible easily to study the band, amplitude, impedance and phase-frequency characteristics of any type of multiplier, in particular, of broadband multipliers and multipliers which do not contain tap filters. Figures 6; references 6: 2 Russian; 4 Western.

[97-8831]

USSR

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MICROPOWER INVERTERS BUILT WITH MOS-TRANSISTORS

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YAKIMAKHA, A. L.

[Abstract] Three micropower logic inverters built with MOS transistors and operating in the depletion mode are considered. The standard device draws zero power under quiescent conditions and consists of two complementary transistors, both gates tied together at the potential input and both drains tied together at the inverter output. It features a high interference immunity, but low threshold voltages are difficult to attain at any one crystal. In the second version both substrates are tied together

at the potential input and both drains a.c. tied together at the inverter output, while each gate is connected to a bias source, this configuration making low threshold voltages unnecessary. In the third version there is only one transistor, with the substrate-drain p-n junction acting as the load. The voltage switching characteristics and the gain of each device are calculated from fundamental inverter performance characteristics and the solution to the Poisson equation for a semiconductor surface, assuming a surface layer of the substrate semiconductor whose nonideality does not depend on the voltage applied across the p-n junction and disregarding any modulation within the flat range of the drain characteristics. Prototypes of the second version were built with pairs (n- and p-) of 164LP1 microcircuit transistors. Prototypes of the third version were built with KP301B transistors having an induced channel. Both versions were tested and their performance checked experimentally. Figures 2; references 12: 7 Russian; 5 Western.
[156-2415]

USSR

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THEORETICAL AND PRACTICAL DEVELOPMENTS IN INTEGRAL MAGNETIC HEADS

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 12-20 manuscript received 18 Jul 79

KHALETSKIY, M. B., TIKHONOV, A. A., IVANOV, A. E. and GLEBOV, G. M.

[Abstract] Integral magnetic recording heads with narrow pole shoes are considered, including vertical and horizontal single-turn as well as multturn constructions. They all consist essentially of a substrate on which magnetic carriers and an electrical conductor are deposited so as also to form the necessary gap. The magnetic carriers can be thin ferrite films, and the substrate can also be a ferrite layer constituting a part of the flux carrier. The magnetic leakage fields are calculated theoretically in a two-dimensional approximation on the basis of micromagnetic analysis, assuming an equiprobable linear or parabolic (second-degree) magnetization profile and taking into account the effect of a bounded active surface. The performance characteristics of various gradually improved designs have been determined experimentally, in the recording mode and in the playback mode with magnetic tapes and disks, indicating a superiority of integral magnetic heads in the frequency range above 10 MHz. Their main advantages are small dimensions accommodating a high transverse recording density and ensuring excellent frequency characteristics. In a multitrack configuration it is possible to maintain an identity of functional track characteristics. It is furthermore possible to mount such heads and IC preamplifiers on the same substrate. Figures 7; tables 2; references 66: 26 Russian; 5 East German; 35 Western.
[156-2415]

USSR

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EXPERIMENTAL INVESTIGATION OF JOSEPHSON JUNCTIONS WITH A SEMICONDUCTOR BARRIER AND OF SUPERCONDUCTOR-SEMICONDUCTOR CONTACTS

Moscow Radiotekhnika i ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2320-2325 manuscript received 23 Dec 77 after revision, 16 Mar 79

ALFEEV, V. N., GRUSHA, S. A., KUZNETSOV, G. V. and UGRIN, M. I.

[Abstract] Generalized results are given of a many-years experimental study of structures based on superconductor-semiconductor-superconductor (S-P-S) and superconductor-semiconductor (S-P) junctions, employing amorphous and monocrystalline semiconductors. Studies were made of conditions for the formation of a potential barrier at the interface of a superconductor and semiconductor and of the electrical characteristics of junctions thus obtained. S-P-S structures manifest the Josephson effect, and S-P structures anomalously great nonlinear resistive effects. Structures of these sorts can find an application in cryoelectronic equipment. For the purpose of producing superconductor - amorphous germanium - superconductor tunnel structures the usual technique was employed of vacuum spraying with cooling of the substrate to the temperature of liquid nitrogen. A modernized UVN-2M-1 unit was employed to produce junctions, which made it possible to avoid the formation of a natural oxide on the lower superconducting electrode. Along with the fabrication of experimental structures, control samples of germanium films were sprayed onto a pyroceramic or sapphire substrate, and these samples were studied with an ER-100 electron-diffraction camera. It was found that the films of the samples had an amorphous structure with crystallites measuring less than 100 Å. The thickness of the germanium film on the control samples was measured by means of an MII-4 interferometer. Immediately after they were produced and checked visually, the experimental samples were mounted on a special holder and immersed in a cryostat with liquid helium. The unit for investigation of electrical characteristics made it possible to measure the volt-ampere characteristic, dU/dI and $I_c(H)$ in the temperature range of 30 to 2.5°K. The most typical results are given for superconductor - amorphous germanium - superconductor junctions which withstood multiple thermal shocks from 300 to 4.2°K and prolonger storage at room temperature. The results are given for Pb-Ge-Pb, Pb-Ge-Sn and p-type Pb-GaAs junctions. The dependence of the critical current through the junction on the magnetic field is of a periodic nature; under the effect of radiation with a frequency of 30 GHz, on the volt-ampere characteristic are evidenced characteristic steps which confirm the Josephson properties of these junctions. The maximum value of the critical current density in Josephson junctions with a semiconductor barrier equals 10^3 A/cm² without noticeable overheating and hysteresis of the volt-ampere characteristic. These observations hold true when the thickness of the semiconductor film is less than 300 Å. Volt-ampere characteristics are presented for the same

junction at different temperatures. With $T \leq 4.2^{\circ}\text{K}$ a superconducting current on the order of magnitude of 10 mA flows through the junction, and is reduced with a rise in temperature, and with $T > 5^{\circ}\text{K}$ the volt-ampere characteristic takes on the shape typical of single-particle tunneling. The tunneling effect in S-P junctions was observed steadily in the impurity concentration range of from $5 \cdot 10^{18} \text{ cm}^{-3}$ to $7 \cdot 10^{19} \text{ cm}^{-3}$ for p-GaAs, from $2 \cdot 10^{18}$ to $3 \cdot 10^{19} \text{ cm}^{-3}$ for p-Ge, and from $1 \cdot 10^{18}$ to $5 \cdot 10^{18} \text{ cm}^{-3}$ for p-InSb. As superconductors were used Pb, Sn, Nb and In. Typical characteristics are presented for superconductor-semiconductor junctions as a function of different external conditions. Curves are shown, illustrating the dependence of the differential resistance on the bias voltage in the junction at different temperatures for a sample of p-type Pb-GaAs with a carrier concentration of $p = 1 \cdot 10^{19} \text{ cm}^{-3}$. Also illustrated is the influence of a magnetic field on the characteristics of this same sample. The influence of temperature and a magnetic field on these characteristics is evidenced chiefly by a change in the parameters of the superconducting electrode. The semiconductor also exerts some influence. A growth in the strength of the magnetic field, as well as a rise in temperature, results in a reduction of the differential resistance of the junction. With microwaves acting on the junction its differential resistance, beginning at a certain critical value of the applied strength, drops linearly as the result of the disruption of superconductivity by the microwave field. In this regard, conflicting results have been obtained. It is thought that the effect of microwave radiation on superconducting structures can result in an increase in the power gap. The authors thank B. M. VUL and A. M. PROKHOROV for discussion of the results of the work. Figures 6; references 21: 11 Russian; 10 Western.

[97-8831]

USSR

UDC 621.37/39:534

AMPLITUDE AND PHASE MODULATION OF SURFACE ACOUSTIC WAVES IN A LAYERED
LiNbO₃-CdSe STRUCTUREMoscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2197-2202 manuscript received 31 Oct 78

MANSFEL'D, G. D., ORLOVA, G. A. and GULY.YEV, YU. V.

[Abstract] The results are given of a theoretical and experimental study of amplitude and phase modulation of surface acoustic waves in a layered structure consisting of an LiNbO₃ piezoelectric substrate on the surface of which were excited and propagated Rayleigh surface acoustic waves and to whose surface was applied a thin film of a photoconducting CdSe semiconductor. The analysis is based on the fact that electron absorption and the speed of ultrasonic waves in a piezoelectric semiconductor depend substantially on the strength of the longitudinal electric field relative to the direction of propagation of ultrasound. In an alternating electric field the amplitude and phase of the ultrasonic wave at the exit from the crystal are modulated at the field's frequency. The film's illumination level was varied by means of a light source, making it possible to vary over a wide range the concentration of electrons in the film and thus to vary the conditions for their interaction with surface acoustic waves. On the surface of a polished substrate of Y-cut LiNbO₃ along the Z line were propagated Rayleigh surface acoustic waves with a frequency of approximately 30 MHz. Electroacoustic transducers of the opposing pin type were employed for the purpose of selecting and detecting these waves. Directly to the surface of the substrate was applied a photosensitive CdSe film approximately 2 μ thick, 5 mm long and about 2 mm wide. A light source was employed to control the concentration of carriers in the film by varying the illumination intensity. The 30 MHz signal was fed to and processed by a G4-116 generator and the electromagnetic signal representing the surface acoustic wave having passed through a region of the film was transmitted to an S1-75 oscilloscope (which made it possible to monitor the signal's shape), an S4-28 spectrum analyzer and an FK2-12 phase meter. A study was made of the amplitude and phase characteristics of the layered structure as a function of the constant electric field and of phase and amplitude modulation of the surface acoustic wave by the sinusoidal signal by connection of the CdSe film via ohmic contacts to either a direct voltage source or a G3-33 low-frequency oscillator, or to a G4-68 amplitude-modulated high-frequency oscillator, respectively. Curves are derived, illustrating the change in phase of the output signal as a function of the constant electric field in the film and the dependence of electron absorption on the constant electric field in the film. The spectra of phase modulation of surface waves and of an amplitude-modulated signal are shown, along with an example of an oscillogram of an amplitude-modulated

signal. Curves are shown, illustrating the dependence of the amplitudes of the carrier and first three sideband frequencies on the modulation index, giving a comparison of theoretical and experimental results. Good agreement is observed. The conditions are found under which one of the types of modulation predominates. Aspects are discussed of the modulation of surface acoustic waves by a signal of complex form. The significance of the study lies in the fact that for the first time an experimental observation has been made of the phenomenon of the direct modulation of a surface acoustic wave at the modulation frequency of a variable electric field applied to a semiconductor film. The authors thank I. M. KOTELYANSKIY for preparation of the layered structures of LiNbO_3 -CdSe and the highly efficient electroacoustic transducer. Figures 5; references 8: 5 Russian; 3 Western.

[97-8831]

USSR

UDC 621.372.8.001.24

FIELDS IN TAPERED MULTIMODE WAVEGUIDES AND NATURAL VIBRATIONS OF OPEN CAVITIES

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2185-2096 manuscript received 4 Dec 78

BOROVIKOV, V. A.

[Abstract] Expressions are derived for the amplitudes of waveguide modes and for fields excited in slowly tapering multimode waveguides by the incident mode. It is assumed that a certain cross section of the waveguide is critical and it is therefore necessary to consider simultaneously the reflection of the incident mode from this cross section and its retransformation into near modes, which are also reflected. The approach used is that of finding an asymptotic solution to a system of equations from the method of cross sections. The asymptotic form of the field is found near the critical cross section and remote from it. Considered as particular cases are a symmetric tapering waveguide with ideally conducting walls with plane and cylindrical cross sections and a "tapering" refraction waveguide. Equations are found for the field and for the caustic curve. The results are employed for the purpose of calculating natural vibrations in open resonator cavities. The basis of this approach is the fact that an open cavity with concave reflectors with a radius of curvature which is great in comparison with the distance between them can be considered a continuously irregular waveguide which tapers toward both ends. A natural vibration of this type of cavity can be regarded as a waveguide mode which becomes itself after two reflections from critical cross sections at the ends of the waveguide. Expressions are found for natural frequencies which generalize the familiar equations for vibrations of the "bouncing ball" type discussed in earlier studies (1966 and 1972). The results arrived at represent a generalization for the case of the reflection of the field from a critical cross section, of earlier studies by the same author (1977 and 1978). These results are applicable for any waveguide system in which the amplitudes of the waveguide modes satisfy the system of equations upon which the analysis here is based. This system is solved, the consequences of the equations derived are discussed, and examples are considered, i.e., that of a symmetric waveguide with ideally conducting walls by employing the method of plane cross sections and the method of cylindrical cross sections, and the case of a symmetric "tapering" refraction waveguide. It is assumed that the incident mode has a high number of half-waves between the reflectors, i.e., the walls of the waveguide, and this number is in part a function of the characteristic width of the waveguide. Figures 2; references 10: Russian.
[97-8831]

THEORY OF WAVES IN OPEN GRADIENT FIBER LIGHT GUIDES

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
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KOLESNIKOV, P. M., MARTYNNENKO, O. G. and RUDENOK, I. P.

[Abstract] A precise analytical theory is constructed for symmetric H_{0n} and E_{0n} waves in a gradient fiber light guide with generalized spatial inhomogeneity of the dielectric constant described by the equation $\epsilon(r) = \epsilon(0)(1 - ar^2 + br^4)$, $\nu = \nu_0$, where $\epsilon(0)$ is the value of the dielectric constant on the fiber's axis and a and b are gradient parameters. Outside the core, material characteristics are given in the form of the constants ϵ_2 and ν_0 . With the existence of axial symmetry the Maxwell equations for monochromatic radiation break down into two independent systems which describe the propagation of H_{0n} and E_{0n} waves, and from these systems of equations are gotten equations for the tangential components of the electric and magnetic fields, taking into account the above equation for the spatial inhomogeneity of the dielectric constant. The variables are separated in these equations and equations are found for a function depending on coordinate r for the case of H_{0n} and E_{0n} waves. These equations are in turn transformed into dimensionless equations. Particular solutions to the first of these equations represent new special functions of mathematical physics which can be used in order to solve a variety of boundary value problems in the mathematical transfer theory. An explicit expression is written for the azimuthal and longitudinal components of the electric and magnetic fields. Dispersion equations are derived for the H_{0n} and E_{0n} waves of a gradient fiber light guide. Equations are given for critical wave numbers. Curves are given, illustrating the dependence of the internal wave number and external wave number of the first three H-modes on the normalized diameter with $a = 10^{-2}$ and $b = 10^{-4}$ for specific values of the dielectric constant ratio and of normalized group retardation on the normalized diameter for $a = 10^{-2}$, $b = 10^{-4}$ and $a = 0$ and $b = 0$ with the dielectric constant ratio equaling 0.9804. It is shown that with a change in gradient parameters the dispersion characteristic shifts toward higher internal wave numbers for the entire range of normalized diameters considered, with a simultaneous increase in critical normalized diameters. The dispersion curves approach a linearly ascending function. Sensitivity to a change in gradient parameters is determined by the ratio of dielectric constants: With an increase in this ratio a considerable influence on the behavior of dispersion curves is gained when gradient parameters a and b are low, and with $a \neq 0$ and $b \neq 0$ the slope of curves for external wave numbers is reduced. Even with very low values of gradient parameters the normalized

group retardation in a gradient fiber reaches its maximum value much more quickly than in an ordinary fiber. With an assigned number of guided modes it is possible to indicate a normalized diameter with which there is no difference in normalized group retardation. The purely transverse gradient of the dielectric constant has a substantial influence on key characteristics. Figures 3; references 4: 3 Russian; 1 Western.
[97-8831]

USSR

UDC 621.372:621.315.61

ELECTROMAGNETIC WAVES IN GRADIENT FILM WAVEGUIDES

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
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KOLESNIKOV, P. M. and RUDENOK, I. P.

[Abstract] A precise theory is developed for electric and magnetic waves in dielectric gradient film waveguides when the spatial profile of the relative dielectric constant of the guiding layer varies along the transverse coordinate in gradient form, described by the equation

$\epsilon_2(x) = \epsilon(0)(1 - ax^2 + bx^4)$, where $\epsilon(0)$ is the dielectric constant at the center of the film, a and b are gradient parameters and x is the transverse coordinate. The gradient and uniform layers are not bounded along one transverse axis (axis Oy) and the waves are propagated in the direction of axis Oz. The thickness of the gradient layer along axis Ox equals $2x_0$, and it is assumed for simplicity that $\epsilon_3 = \epsilon_1 = \epsilon$ and $\mu_1 = \mu_2 = \mu_3 = \mu_0$, where μ_0 is the magnetic permeability of a vacuum.

Various symmetric spatial profiles of the material characteristics of a gradient film waveguide can be produced by changing gradient parameters a and b in the equation given above. Wave equations are derived for the transverse components of the electric and magnetic fields on the basis of Maxwell equations for harmonic fields. Dimensionless equations are found for these equations and on the basis of a solution of the dimensionless equations special functions are found which describe electromagnetic waves in inhomogeneous waveguide systems. Special functions are derived which make it possible to solve boundary value problems in wave optics, acoustoelectronics and thermophysics. Dispersion equations are derived for odd and even H_n and E_n waves. Equations are also presented for determining critical internal wave numbers. With $\epsilon/\epsilon(0) \rightarrow 1$, the degree of influence of gradient parameters increases markedly. An increase in critical wave numbers is characteristic of a successive reduction in the difference between dielectric constants at the interface of the internal and external layers. When there is no

sudden change in dielectric constant at the boundary of a gradient film, the influence of gradient parameters increases substantially. A computation of the longitudinal component of the "new" Poynting vector in the region of a gradient film demonstrates a considerable concentration of energy around the central plane, as compared with an ordinary film. A gradient film is apparently less sensitive in terms of losses to technological and other flaws in the film's surface. Shown graphically are a dispersion characteristic and the dependence of the normalized phase delay and the normalized group delay on the normalized dimension. Other things being equal, the expansion of pulses depends chiefly on the dispersion of group delays; this makes it possible to use a gradient film to increase considerably the rate of data transmission without strict stipulations for the maximum permissible length of a gradient film and the width of the signal's transmission band. It is possible to compensate effectively the dispersion of a material by altering gradient parameters if knowledge is had beforehand of the sign of the material's dispersion in relation to the dispersion of a gradient film. The differences in normalized group delays of modes guided by a gradient film is much less than in an ordinary film. The curve for the normalized phase delay rises more smoothly and is shifted in the direction of higher values of the normalized dimension. The dispersion characteristic of a gradient film increases with a more even slope than does that of an ordinary film. Figures 3; references 6: 5 Russian; 1 Western.
[97-8831]

USSR

UDC 621.385.6

OSCILLATIONS AND WAVES IN LADDER NETWORKS OF SIX-TERMINAL NETWORKS DISCRETELY COUPLED WITH AN ELECTRON STREAM

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KANAVETS, V. I., KANDABAROV, V. N. and SANDALOV, A. N.

[Abstract] An analysis is made by the matrix method of the discrete interaction of oscillations and waves in ladder networks of six-terminal networks with an electron stream. The system, the stream and the complex delaying structure are represented as a ladder network of eight-terminal networks. It is possible to produce an artificial region of transmission in coupled structures with positive and negative dispersion, or in the interaction of several types of waves in a single electrodynamic system. The employment of artificial regions of transmission in electronics is of interest because it makes it possible to realize the advantages inherent in traveling-wave tubes with supercritical amplification. The method of coupled waveguide transformers represented as ladder

networks of multi-terminal networks excited by an electron stream has been used to analyze the operation of a traveling-wave tube near the boundaries of the "cold" transmission band and beyond its limits in the linear and nonlinear theory. As a result of the effect of the electron stream, the transmission bands of electrodynamic systems expand and are shifted and the regions of amplification are extended on both sides of the boundary of the "cold" transmission band. Thus, the wave properties of these structures are not fixed but vary under the influence of the electron stream. An illustration is given of several complex delaying systems consisting of two loosely coupled structures with opposite dispersion. Each structure has a transmission band for approximately the same frequency range. Coupling between the structures is selected by varying a capacitance. The electron stream in the section between cells in a linear approximation is represented as an equivalent two-terminal-pair network. An effect is exerted on electrons in the narrow capacitive gaps of a delaying structure with negative dispersion. The delaying structure with positive dispersion is not directly coupled with the stream. The effect of the electron stream on the system is represented as an alternating induced current generator being connected to a certain gap. This current depends on the electron interaction coefficient and the amplitude of the first harmonic of the current in the region of the gap. The electron beam in a gap's outlet is modulated in terms of velocity and this modulation depends on the amplitude of the variable difference in potential in the gap. On the basis of this generalized model, an equation is derived for the excitation of the traveling-wave tube in a linear approximation. An equation is derived for the electron stream, whereby it is assumed that there exists an infinitely great homogeneous magnetic focusing field constant over time, directed along the longitudinal axis. The finite transverse dimensions of the stream are taken into account and the electrodynamic system is substituted for by an equivalent drift tube. The influence of the walls of the drift tube is taken into account by introducing the reduction factor for plasma oscillations. Equations are presented which completely describe the linear discrete interaction of the field of the electrodynamic system and the beam. A dispersion equation is derived which makes it possible to determine the characteristics of a delaying structure in the absence of an electron stream, the dispersion of the waves of the space charge of an electron beam, and the pattern of variation of the dispersion properties of a structure while taking into account the influence of the electron stream. Solutions are presented which make it possible to reveal the nature of interaction of the electromagnetic field with waves of the space charge, and to determine the conditions for the existence of a specific operating mode. Equations are presented which describe separately the properties of the delaying structure and electron stream. A theoretical analysis is made of the interaction of waves of the electron stream with waves of the delaying structure and boundary conditions are taken into account. Oscillations and waves in a "cold" electrodynamic system are discussed, and oscillations and waves in a system with an

electron stream. It is demonstrated that the influence of an electron stream in interaction near the boundary of the band results in merging of the regions of active and passive coupling and the region of reactive attenuation. Generally speaking, just by taking boundary conditions into account it is possible to isolate the region of amplification of a traveling-wave tube from the region of attenuation, and it is demonstrated that in the transmission region attenuation can change to amplification. In coupling structures with opposite dispersion, a transmission region originates which changes under the influence of an electron stream. The authors thank R. A. SILIN and V. A. CHEREPENIN for helpful discussion of the problem. Figures 5; references 6: Russian.
[97-8831]

USSR

UDC 621.385.6.01

MODELING OF DYNAMIC PROCESSES IN INTENSE RELATIVISTIC CURVILINEAR ELECTRON STREAMS

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pp 2298-2307 manuscript received 24 Oct 78

AFONIN, A. M., KANAVETS, V. I. and CHEREPENIN, V. A.

[Abstract] Intense relativistic electron streams can be employed highly effectively for the purpose of generating powerful microwave oscillations. Of topical interest is a study of the influence of the quasi-static and moderating interaction of particles on their emission. Even in experimental instruments employing longitudinal interaction, such as klystrons, the trajectories of individual electrons are curvilinear. A study is made here which represents a development of the procedure for modeling dynamic processes as applied to curvilinear streams. A procedure is suggested for modeling nonlinear dynamic processes in intense relativistic streams guided by a longitudinal static magnetic field. For the case of random motion at relativistic velocities in broad electrodynamic systems a description of emission requires the consideration of many modes of the eddy field. This can be accomplished by a method for separating eddy and Coulomb fields. In the procedure suggested here, a simpler problem is solved, when it is possible to limit oneself to a not too great number of excited modes of the emission field. Non-emitted (entrained) synchronous and asynchronous fields are computed by changing to a moving system of coordinates. Equations are written for a homogeneous circular stream in a waveguide with a specific radius and directed by a magnetic field of specific strength. The spread in velocities at the inlet is disregarded. Harmonic processes which are quasi-periodic in relation to the longitudinal coordinate are considered. Equations of motion are presented for curvilinear streams under the condition of gyroresonance, which are widely

employed in masers employing cyclotron resonance. Net-point methods are employed to take into account Coulomb forces and the intrinsic magnetic field, and included in the equations are the eddy current, which is calculated at each step in integration. For the purpose of solving the equations of motion it is necessary to know the values of the entrained electric and magnetic fields, which are found by changing to a system of coordinates which moves along the longitudinal axis at a rate equal to the mean value of the longitudinal components of the velocities of electrons computed at each step in integration. This method gives correct results for instruments with longitudinal interaction and a sufficiently low spread in velocities. With the assumptions made here, the entrained electric and magnetic fields represent quasi-static fields. An equation is derived for excitation of the emitted field, where the discussion is limited to the excitation of a field of the TE type in the axisymmetric problem. A solution is given to a scalar equation derived for representing quasi-static field equations. A self-consistent solution is found for the equation for excitation of the eddy field, written with the longitudinal axis as the independent variable, and the equations of motion and quasi-static field equations, having the time as the independent variable. As an example of the influence of entrained fields, Coulomb instability of a polyhelical electron stream is discussed, in a drift tube which is supercritical for a high-frequency field. Here there is no synchronism between modes of the field and the beam. The general conclusion is drawn that Coulomb and intrinsic magnetic fields exert a considerable influence on the behavior of dynamic processes in intense relativistic curvilinear streams. A sufficiently effective approximate analysis of nonlinear processes with relativistic energies can be made in many instances by separating the entrained and emitted fields. Fields in intense relativistic curvilinear streams can be computed by netpoint methods and using a moving system of coordinates. The authors thank V. M. LOPUKHIN and A. N. SANDALOV for productive discussion of the work. Figures 4; references 16: 14 Russian; 2 Western.

[97-8831]

USSR

UDC 621.316.729.01

MODELS OF DIGITAL PHASE-LOCKED SYSTEMS

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 pp 2244-2253 manuscript received 3 May 78

BELYKH, V. N.

[Abstract] Mathematical models are constructed for digital phase-locked systems with phase control for the case of binary quantization. Binary quantization is performed by a limiter and phase control by an n_d -fold divider and a device for adding and eliminating pulses from a train of frequency f_n . Digital phase-locked systems are divided into two kinds: System I is used for radio signals and has a mixer and filter; system II is used for radio and video signals and does not employ a mixer and filter. The digital section of both systems contains a digitizer and limiter; an averaging filter contained in a proportional loop which shapes output pulses in keeping with a specific algorithm; an integrating loop containing an averaging filter; an adder-integrator; and a code-frequency converter. The input signal mixed with the noise is represented in the form $u_s(t) = Ag(\phi_s) + \zeta(t)$, where A and g are the amplitude and form of the signal, respectively, $\zeta(t)$ is the additive noise, and the phase of the signal, ϕ_s , has the form $\phi_s(t) = \phi_0 + 2\pi f_s t + v_0 t^2/2$, where $v_0 \neq 0$ corresponds to a linear frequency modulation signal. The phase of the two-level output signal, $\phi_v(t)$, is considered a piecewise linear function with steps equal to $\Delta = 2\pi/n_d$ at the moments of arrival of control pulses from the output of the averaging filter contained in the proportional loop. The change in state of the system is discussed at moments of digitization, t_1 , which are determined variously for different types of digital phase detectors, the role of which here is played by the digitizer and limiter as the quantizing element and the averaging filter in the proportional loop as the adding element. Two methods of digitization are discussed: one producing a delta characteristic for the digital phase detector, designated as the T-case, and one producing a Rayleigh characteristic, called the R-case. The process of phase detection is described for systems I and II for different methods of digitization. The models are presented in the form of difference equations in terms of the mismatch and denumerable coordinates of the system's digital elements. The phase detection process for systems I and II with different methods of digitization is discussed in terms of D_1 , a function characterizing pulses in the input of the averaging filter in the proportional loop, which take on values of ± 1 . The difference equation models derived are simplified to obtain pulsed and continuous analogs. Discrete models in the absence of noise are discussed, in which the steady-state discrete trajectories determining the mode of synchronism depend on the initial conditions and parameters, are periodic or quasi-periodic, and form continuums which fill in regions of positive dimension in the phase space. Stochastic models are discussed, when the digitization period is considerably longer than the period for correlation of $\zeta(t)$, when samples

can be considered independent and the theory of discrete Markov processes can be employed for investigation. Here the difference equations are reduced to a system of functional difference equations in terms of the vector of two-dimensional probability densities in discrete states. A graphic illustration is given of the dependence of the root-mean-square deviation in phase on the signal-to-noise ratio with specific parameters for the case of $g(\phi) = \sin \phi$ and normal noise, as well as the form of steady-state density with not too high noise. Examples are given of investigation of the dynamic and static properties of a system on the basis of the models described. Figures 4; references 20: 18 Russian; 2 Western.
[97-8831]

USSR

UDC 621.382.82

DESIGN OF A MIXER WITH EXTERNAL BIAS

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 58-59 manuscript received 19 Jan 79

YEFREMOV, YU. G., NEVGASIMYY, A. F., SOLGANIK, B. D. and SHERMAREVICH, V. G.

[Abstract] A resistive network is designed which provides a constant positive bias to a mixer so as to lower the heterodyne power and not to make the standing-wave ratio more dependent on the heterodyne voltage. The two resistances, one in series and one in a long shunt, are calculated approximately for a wideband mixer (load at mirror frequency equal to load at signal frequency) built on Schottky diodes and operating with heterodyne voltages not higher than the barrier potential. In a real mixer designed accordingly, the standing-wave ratio is found to remain constant over the power range where conventionally, with a stabilized bias current, it would increase. Figures 2; references 2: Western.
[156-2415]

USSR

UDC 621.396.969.1

AN ALGORITHM OF PROCESSING RADIOTECHNICAL MEASUREMENT DATA

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 60-61 manuscript
received 29 May 79

BORISOV, E. V.

[Abstract] An algorithm of estimating the parameters of an object in motion from several successive measurements is shown which applies, specifically, to motion of an object along a piecewise constant-velocity trajectory. Based on the principle of maximum likelihood, it yields the optimum estimators of distance and velocity with dispersions which are inversely proportional to the number of measurements. Figures 1;

references 1: Russian.

[156-2415]

microelectronics
(Including Microcircuits, Integrated
Circuits, Logic Circuits, Microsensors)

USSR

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OPERATING MODES OF INTEGRATED-CIRCUIT VOLTAGE STABILIZERS

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VEKSLER, G. S., PAVLOVSKIY, L. L. and PILINSKIY, V. V.

[Abstract] Voltage stabilizers built with K142EN1 and K142EN2 microcircuits have, in terms of miniaturization, excellent size and weight characteristics. Here their performance is evaluated on the basis of design relations and experimental data. The performance indicators include maximum load current, minimum and maximum input voltage, and maximum allowable power dissipation. These voltage stabilizers can be made to operate under loads higher than nominal, by external coupling to power transistor states with either a common or a separate primary voltage supply. They can also be designed to drop a load partially or completely without an excessive rise of the input voltage. Figures 5; references 2: Russian.

[156-2415]

USSR

UDC 621.396:535.8

OPTICAL CORRELATOR OF COMPLEX PHASE-MANIPULATED SIGNALS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2360-2363 manuscript received 10 Apr 78

KUZICHKIN, A. V.

[Abstract] In the designing of optical equipment for the optical correlation of complex radio signals, a difficult problem is that of producing reference masks whose transmission function will be proportional to an amplitude copy of the reference signal. A transmission characteristic must be formed for the stereo carrier frequency of the radio signal to be processed. The fact that accuracy must be very high in reproducing the period of the stereo frequency of the incoming signal on the photographic transparency complicates the process of producing reference masks and restricts the broadbandness of signals which can be processed in optical correlators. Here a method is proposed for increasing the broadbandness and simplifying the implementation of optical correlators for complex phase-manipulated signals. The method is based on the use of reference masks on which its code sequence is recorded instead of the reference phase-manipulated signal. The advantage of this method is the fact that the size of the smallest element of the coded transparency is determined not by the period of the carrier frequency of the phase-manipulated signal, $2\pi/\omega_0$, where ω_0 is the angular carrier frequency of the signal, as is the case with a traditional reference mask, but by the duration of an elementary character of the code sequence, $T_0 \gg 2\pi/\omega_0$. A functional diagram is shown of an optical correlator with coded transparencies, which consists of two ultrasonic light modulators which receive the incoming signal. The signal passes through the light modulators to the coded transparencies, and through these to converting lenses which are focused onto photodetectors. In one channel the signal from the photodetector passes through a phasing circuit to a linear summing device, and in the other it passes directly to the linear summing device. Equations are given for the distribution of light formed in the rear focal plane of the converting lens when the ultrasonic light modulator is exposed to coherent light. Equations are given for the distribution of complex amplitudes of the light in the region of the fundamental frequency of the spectral decomposition of the incoming signal. Also given are equations for the electrical signals in the outputs of the photodetectors, operating in the heterodyne detection mode. The resulting output signal of the optical correlator is formed by the phasing circuit and the linear summing device. It is shown that the output signal of the linear summing device is proportional to the correlation function of the incoming and reference signals. It is demonstrated that in an optical correlator with coded transparencies and heterodyne detection an algorithm is realized for optimal coherent filtering of complex phase-manipulated

signals which makes possible the best separation and resolution of signals against a background of fluctuation noise. The design of an optical correlator of this type can be simplified in addition by means of the direct detection of optical signals. With this method, when signals are received against a background of fluctuation noise, the worsening of noise rejection originating from departure from the optimal coherent algorithm for processing the entire signal is quite insignificant and is totally acceptable in practice. An experimental test was made of the method suggested. It was demonstrated that with an increase in the period of the code sequence the degree of the difference of the correlator's output signal from the square of the aperiodic auto-correlation function is reduced substantially. Figures 1; references 5: 3 Russian; 2 Western. [97-8831]

USSR

UDC 519.245

APPLICATION OF STOCHASTIC APPROXIMATION METHODS TO PROBLEMS IN FINDING
THE DIRECTION OF SOURCES OF RANDOM FIELDS WITH UNKNOWN PARAMETERS

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 24 No 11, Nov 79
pp 2363-2367 manuscript received 9 Mar 77

RYBAKOV, B. S.

[Abstract] In finding the direction of sources of random fields whose parameters are unknown at the receiving point, the bearing is usually read with reference to the mean direction finding characteristic in terms of the set of three-dimensional realizations of the field and noise. A priori indefiniteness regarding field parameters results in indefiniteness in selection of the direction finding characteristic of the measuring system. The algorithm for the system's operation is then constructed either on the basis of the adaptive Bayes approach or by using iteration methods of stochastic approximation. The use of iteration methods makes possible asymptotic convergence of the estimate with the true value of the parameter over a sufficiently broad range. A theoretical discussion is given of the application of iteration methods of stochastic approximation for four types of goniometric systems: AA, AF, FF and FA, where the first letter designates the type of receiving antenna and the second type of measuring system, where A stands for amplitude and F for phase. The measuring system's output voltage is designated by the random magnitude e , the distribution function of which, $F(e/\theta)$, depends on parameter θ_0 . Unknown is regression function $R(\theta)$, representing the mean direction finding characteristic, where $\bar{e}(\theta) = R(\theta)$. The form of function $F(e/\theta)$ and thus of $R(\theta)$ is determined by the properties of the field and noise and by the method of direction finding, i.e., the method of converting the signal and noise in the direction finder. The direction finder's antenna system performs rapid azimuthal scanning and is controlled from results of measuring the output voltage, $e(\theta_n)$, whereby at the next $(n+1)$ -th step it occupies an angular position of θ_{n+1} . An estimate of the bearing, θ^* , is found by solving the equation $R(\theta) =$ by means of the equation $\theta_{n+1} = \theta_n + a_n[\epsilon - e(\theta_n)]$, where $\epsilon = \text{const}$. The conditions are written for the convergence of sequence θ_n with the true value θ_0 with $n \rightarrow \infty$. This procedure represents a solution to the non-parametric problem of finding constant parameter θ_0 . For the purpose of testing the conditions for conversion, the parameters of the received field and noise are made specific. Equations are derived for the first two moments of the output voltage of measuring systems for the case of random values of the field coherence parameter, for an amplitude-type measuring system with linear and logarithmic processing, and for a phase-type of measuring system. It is demonstrated that the regression functions for all types of systems and kinds of processing satisfy convergence conditions, i.e., approach the direction finding characteristics of systems under regular

conditions, i.e., in the absence of a scattered field component and of noise. $R(\theta_0) = 0$ for FF and AF systems and AA and FA systems with logarithmic processing over the entire range of variation of field parameters and noise. For AA and FA systems in linear processing, the value of $R(\theta_0)$ depends substantially on the properties of the field and noise. The variance in fluctuations of the output voltage of the measuring system is minimal at point $\theta = \theta_0$, all other things being equal. In employing the algorithm suggested above in FF and AF systems, as well as in the AA and FA systems with logarithmic processing, it is necessary to assume that $\alpha = 0$. It is not feasible to employ this algorithm in AA and FA systems with linear processing. A modified algorithm is suggested, in the form of $\theta_{n+1} = \theta_n + a_n \text{ sign } [\text{as published}] (\theta_n)$. This algorithm is recommended for use in FF and AF phase measuring systems and in AA and FA amplitude measuring systems and logarithmic processing systems in the reception of scattered fields alone. References 14: 10 Russian; 4 Western. [97-8831]

USSR

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DETECTION OF SIMPLE AND COMPLEX SIGNALS APPEARING WITH REVERBERATION INTERFERENCE

Moscow RADIOTEKHNIKA in Russian Vol 35 No 1, Jan 80 pp 61-64 manuscript received 29 Mar 79

KOVALENKO, L. N., KRASNYY, L. G. and SKRIPKA, N. I.

[Abstract] Detection of simple and complex signals is considered when they appear with only fluctuation but also reverberation interference, namely with echo signals subject to a Doppler-effect frequency shift. The optimum receiver-correlator in each case is described by an appropriate convolution integral and its interference immunity is defined in terms of the signal-to-noise ratio at the output. In the case of a signal with linear frequency modulation, a comparison between a nonoptimum receiver which does not take care of reverberation and an optimum one which does indicates a relatively small improvement in interference immunity which is significant only and does not exceed 3 dB for simple signals and small Doppler shifts. In radar, therefore, it is sometimes most expedient to use either tone signals or complex signals with nonoptimal correlators or matched filters disregarding reverberation. Figures 2; references 3: Russian. 1 Western (translated).

ESTIMATE OF SIGNAL AMPLITUDE AND ANGULAR COORDINATES OF THE TARGET IN ADAPTIVE SEQUENTIAL DETECTION

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pp 2203-2211 manuscript received 10 Apr 78

KUZ'MINA, YE. K. and MIKHAYLITSKIY, V. P.

[Abstract] The problem is discussed of estimating the amplitude of the reflected signal and angular coordinates of a non-fluctuating target from data delivered to a pulsed surveillance radar station with adaptive sequential detection when operating with Gaussian noise of varying intensity. It is assumed that in surveillance the directivity diagram of the antenna moves along two angular coordinates ξ and β discretely in steps equaling $\Delta\theta_\xi$ and $\Delta\theta_\beta$ and has a half-power width of θ_ξ and θ_β in planes ξ and β respectively. The target is detected in each direction independently from an incoherent packet of n pulses whose number is determined by the adaptive sequential procedure. The problem of measuring target parameters is considerably complicated when the noise is of a non-steady-state nature, when its intensity can vary over the period of a single echo. An adaptive sequential detector utilizes an estimate, $\hat{\sigma}_1$, produced in the receiver, of the intensity of the noise, σ_1 , for the purpose of computing a generalized plausibility relation, $z_1(v_1, \hat{\sigma}_1)$, when detecting in the direction sounded an i -th reading of the voltage, v_1 , in the receiver's output. In detecting a target in a number of adjacent directions it is possible to estimate angular coordinates and the amplitude by weighing individual estimates of amplitudes computed by taking into account the current estimate of the noise, $\hat{\sigma}_1$. Here key calculation algorithms are presented and an analysis is made of the accuracy of individual estimates of amplitudes and of estimates of angular coordinates and amplitudes for a unidimensional packet of signals obtained in a number of adjacent sounding directions, and of estimates of angular coordinates and amplitudes for a two-dimensional packet of signals formed with a radar antenna's directivity diagram scanning in two orthogonal planes. Adaptive algorithms are arrived at for estimating the amplitude and angular coordinates which makes it possible to smooth out unequally accurate readings of the received signal while taking into account an estimate of the dispersion of the noise computed in the detector. Mathematical modeling is employed to estimate the accuracy of the algorithms. Accuracy in the estimation of signal parameters is maintained by regulation of the size of the pulse packet, which is accomplished by the adaptive sequential detector, and by adaptation of the algorithms for estimating parameters to the intensity of the noise. The authors thank B. A. POZANOV and I. B. VLASOV for helpful discussion of the material of the work.

Figures 6; references 4: Russian.

[97-8831]

USSR

UDC 621.315.592

THERMAL DOMAINS IN SEMICONDUCTORS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11,
Nov 79 pp 2081-2086 manuscript received 18 Dec 78

SAFRONOVA, O. I.

[Abstract] Joule-effect heating is considered in a semiconductor when a nonuniform steady-state longitudinal temperature profile or a thermal domain forms. The stability threshold of a thermal domain relative to vanishingly small perturbations is established and compared to that of a uniform steady-state longitudinal temperature profile. Calculations are based on the equation of heat conduction and the relation between electric field and temperature field parameters. The current-voltage characteristic of a semiconductor with a thermal domain is also calculated accordingly, and found to follow an N-curve with possible transitions producing a hysteresis loop. The author thanks V. M. YELEONSKIY for discussion of the results of the work and for valuable comments. Figures 6; references 6: 5 Russian; 1 Western.

[133-2415]

USSR

UDC 621.315.592

AUGER RECOMBINATION h-h-e IN SILICON

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11,
Nov 79 pp 2096-2099 manuscript received 26 Dec 78

GRIVITSKAS, V. and VAYTKUS, YU., Vil'nyus State University imeni
V. Kapsukas

[Abstract] Auger recombination of one electron with two holes has been discovered in highly doped and weakly excited p-type silicon, and found to be as intensive within the 77-400 K temperature range as recombination of two electrons with one hole. This is explained by a lower activation energy in the 24 equivalent to $\langle 110 \rangle$ directions in the k-space. The activation energy is calculated from the laws of energy and quasi-momentum conservation, representing an isoenergetic surface of heavy holes in the valence subband as ellipsoids and taking into account nonparabolic dispersion in these $\langle 110 \rangle$ directions. Calculations yield an activation energy ranging from 25 to 125 meV and, based on a more accurate linear dispersion, its actual value would be equal to the average of 75 meV.

[133-2415]; tables 1; references 7: 1 Russian; 6 Western.

USSR

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DEVELOPMENT OF CONVECTIVE INSTABILITY OF RECOMBINATION WAVES

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2135-2138 manuscript received 21 Jul 78; finally edited 30 Mar 79

KARPOVA, I. V. and SABLIKOV, V. A., Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow

[Abstract] Excitation and the kinetics of fast recombination waves are analyzed, the results indicating a convective nature of instability and an amplification of density fluctuations by a spatial redistribution of charge carrier concentration. Theoretically this is demonstrated by considering the drift of a plasma density jump which has been injected at the boundary of a semiinfinitely long medium with a subsequently maintained constant excess hole concentration at that boundary. The conclusions have been confirmed experimentally, allowing for discrepancies due to a measurement time much longer than the lifetime of charges. Tests were performed in a medium with a nearly intrinsic carrier concentration, an electron entrapment rate of $1.5 \cdot 10^5 \text{ s}^{-1}$ and a hole entrapment rate of $5 \cdot 10^4 \text{ s}^{-1}$. Agreement with theory is closest assuming an electron concentration of $3 \cdot 10^{13} \text{ cm}^{-3}$ and a hole concentration of $2.3 \cdot 10^{13} \text{ cm}^{-3}$, a wave front with a velocity of $1.5 \cdot 10^4 \text{ cm/s}$ reaching the probe within $4 \cdot 10^{-6} \text{ s}$. The authors thank V. B. SANDOMIRSKIY for discussion of the work. Figures 3; references 5: Russian.

[133-2415]

USSR

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ANISOTROPIC SIZE EFFECT ASSOCIATED WITH SPIN POLARIZATION IN A SEMICONDUCTOR

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2139-2142 manuscript received 9 Apr 79

PIRAGAS, V. A., Institute of Semiconductor Physics, Academy of Sciences of the Lithuanian SSR, Vil'nyus

[Abstract] Spatial redistribution by a quantizing magnetic field of electrons in a semiconductor is considered where the electrons have different spin directions and a mobility anisotropy. The anisotropy is due to the Hall effect and to the dependence of the density of electron states on the direction of the spin. On the basis of the equation for the excess concentration and on InSb with large Shubnikov - de Haas oscillations as a model, the effect of nonequilibrium spin polarization

of conduction electrons on the absorption signal at electron-paramagnetic resonance is demonstrated in the case where spin-lattice relaxation occurs within different lengths of time at different boundaries of the semiconductor specimen. In a matched magnetic field, accordingly, an electric field will intensify that absorption signal. This effect is strongest in the case of a spatially slow spin relaxation and also a slow momentum relaxation. References 8: 5 Russian; 3 Western.
[133-2415]

USSR

UDC 621.315.592

CATHODOLUMINESCENCE OF UNDOPED GALLIUM NITRIDE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2153-2159 manuscript received 16 Apr 79

VAVILOV, V. S., MAKAROV, S. I., CHUKICHEV, M. V. and CHETVERNIKOVA, I. F. Moscow Institute of Aircraft Technology imeni K. E. Tsiolkovskiy; and Moscow State University imeni M. V. Lomonosov

[Abstract] An experimental study was made of gallium nitride as a cathodoluminescent material, without doping and thus with an unmeasurable impurity content. Specimens for this study were grown epitaxially on (0001)-oriented sapphire by the standard chloride-hydride process at 1050°C at a rate of 0.5-1 $\mu\text{m}/\text{min}$. Cathodoluminescence was excited at temperatures from 8 to 300 K by an electron beam accelerated to 10-40 keV energy levels from an electron gun operating in the pulse mode (current density 0.03-0.5 A/cm², pulses of 0.4 μs duration at a 200 Hz repetition rate). Measurements were made with instrumentation consisting of a photoelectron multiplier as the radiation receiver, a monochromator-spectrometer, a synchronous detector and an automatic recording device. The results confirm the exciton nature of radiation lines at the short-wave edge at helium temperatures, but do not explain the nature of donor and acceptor states in gallium nitride. They suggest the existence, beside the fine donor state with 17 meV ionization energy, of a donor level with a 110 meV ionization energy yielding intensive radiation with a 3.39 eV peak at 8 K and also of an acceptor center 200 meV above the valence band yielding radiation within the 3.30 eV band. Figures 3; references 16: 3 Russian; 13 Western.
[133-2415]

USSR

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HALL MOBILITY IN THE IMPURITY ZONE OF p-TYPE GALLIUM ARSENIDE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2164-2167 manuscript received 14 Jun 78; finally edited, 20 Apr 79

VELICHKO, A. A., PALKIN, A. M. and KRAVCHENKO, A. F., Institute of Semiconductor Physics, Siberian Department of the USSR Academy of Sciences, Novosibirsk

[Abstract] A study was made of galvanomagnetic effects in the impurity zone of p-GaAs semiconductors. Film specimens were either grown epitaxially from the liquid phase or cut from bulky single crystals, then doped with zinc. Subsequently the Hall mobility of charge carriers in the impurity zone was measured as a function of the temperature from 4 to 400 K, of the acceptor concentration, and of the degree of compensation. The experimental results differ somewhat from theoretical calculations based on a δ -form scattering potential, probably because real semiconductors have a close to a shielded Coulomb potential and because the calculated degree of compensation does not depend on the form of the potential when the scattering is weak. Figures 3; tables 1; references 11: 7 Russian; 4 Western. [133-2415]

USSR

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PRACTICALLY ATTAINABLE SPATIAL FREQUENCY IN HOLOGRAM RECORDING BY THE METHOD OF LIGHT-SENSITIVE ETCHING OF SEMICONDUCTORS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2173-2179 manuscript received 27 Apr 79

BELYAKOV, L. V., GORYACHEV, D. N., RYVKIN, S. M., SRESELI, O. M. and SURIS, R. A., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] In connection with hologram recording by light-sensitive etching of semiconductors, the effect of nonuniform illumination of the semiconductor surface near strong electric fields on the distribution of excess minority charge carriers is considered with both diffusion and self-induced drift taken into account. The space-charge region is assumed to absorb the entire luminous flux. The analysis, based on the differential equation of continuity, applies to photochemical as well as photoanodic etching. The light-modulation index is determined from the solution to this equation, linearized under simplifying assumptions, as a function of

certain semiconductor and electrolyte properties. Higher spatial frequencies are found to be attainable on a more strongly doped semiconductor, with more depletion bending of the surface bands, and with faster electrochemical recombination. The maximum frequency is thus determined by the concentration of majority charge carriers and by the width of the space-charge region, which explains the poor photo-chemical etching of compensated high-resistivity gallium arsenide. At high values of the modulation index the theoretical dependence of the latter on the spatial frequency departs from the experimental curve, because of the error of calculations in this range, while in the range of high spatial frequencies the experimental curve has a tail where the modulation index is low but remains constant. Figures 2; references 8: 5 Russian; 2 Western.
[133-2415]

USSR

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ACTIVATION ENERGY OF HOPPING CONDUCTION IN WEAKLY DOPED SEMICONDUCTORS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2192-2209 manuscript received 14 May 79

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[Abstract] The temperature dependence of electrical resistivity in a weakly donor-doped semiconductor at very high temperatures, at which conduction hopping over neighboring impurities takes place, is analyzed and the activation energy of this hopping conduction is calculated with the aid of an already available computer program dealing with the structure of the impurity zone over a wide range of compensation. The calculations involve determining the breakaway threshold according to the boundedness criterion, using the data for a large cube with given donor and acceptor coordinates at temperature $T=0$. In the range of higher temperatures the activation energy drops fast with decreasing temperature, which is explained by the theory of perturbations but cannot be confirmed experimentally because of the shunting effect of the conductance of free electrons. The activation energy levels at lower temperatures, remaining constant at a low value, which can be confirmed experimentally. Taking into account electron-electron correlations yields a close agreement with experimental data at compensation levels up to $K=0.7$, but at higher compensation levels the discrepancy widens because the resistivity also increases. Figures 5; references 12: 5 Russian; 7 Western.
[133-2415]

EFFICIENCY OF ELECTROLUMINESCENCE IN P-N JUNCTIONS OF GALLIUM ARSENIDE DOPED WITH SILICON

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2227-2232 manuscript received 21 Jul 78; finally edited, 13 Jun 79

BASKIN, E. M., VINKE, A. L., LIKENKER, B. S. and SIDOROV, V. G., Vologod-skiy Polytechnic Institute

[Abstract] A study of GaAs <Si> light-emitting diodes and the dependence of the external quantum yield of electroluminescence on the silicon concentration in the solution-melt reveal an important role played by fluctuations of the impurity potential in the process of radiative recombination. The quantum yield first increases with increasing silicon concentration, because spontaneous absorption decreases exponentially at energy levels lower than the energy gap, and then decreases after peaking at an optimum silicon concentration because of several possible factors. Here the effect of potential fluctuations on the mechanism of energy loss is analyzed, assuming that such fluctuations are optimum and that the p-region emits radiation. Into account are taken the temperature dependence of emission and thermally facilitated tunneling, shown both theoretically and experimentally to have a decisive effect on the recombination process. This process and thus the peak as well as the half-width of the emission line, and also the speed of a light-emitting diode, can be controlled by independently changing the amplitude and the characteristic radius of the impurity potential through varying the dopant concentration, the compensation level, or the temperature. The effect of nonradiative recombination in GaAs <Si> diodes on the quantum yield must be further studied. Figures 5; references 11: 10 Russian; 1 Western. [133-2415]

n-Si-p-GaSe HETEROJUNCTIONS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2237-2239 manuscript received 26 Jun 79

KYAZYM-ZADE, A. G., DZHAFAROV, D. KH. and TAGIROV, V. I., Azerbaijan State University imeni S. M. Kirov, Baku

[Abstract] Heterojunctions n-Si-p-GaSe were produced by the method of direct optical contact at 300 K, using phosphorous doped n-Si single crystals (carrier concentration $\sim 10^{16} \text{ cm}^{-3}$) and p-GaSe single crystals (carrier concentration $\sim 10^{14} \text{ cm}^{-3}$). With metallic indium used for contact tabs, current-voltage and capacitance-voltage characteristics of these n-Si-p-GaSe heterojunctions were measured also at 300 K. The trend of the current-voltage characteristic, linear in the forward range above 0.80 V and parabolic in the reverse range above 1.2 V, indicates the typical behavior of a diode. With increasing forward bias, the differential resistance of such a heterojunction approaches the resistance of its GaSe layer. Breakdown of the junction occurs at a reverse bias of 6-10 V. The high current transfer ratio β is attributable to the voltage drop across the dielectric gap between contacting surfaces and the usually 15-20 Å thick SiO_2 film building up on the silicon surface. The trend of the capacitance-voltage characteristic, $C^{-2} = f(V)$ being linear and $C=0$ at $V = -1.05$ V, indicates an ideally sharp junction. The energy band structure was determined on the basis of "bulk" parameters, the flexure of energy bands at the free surface of contacting materials having been measured by the method of saturated surface photo-emf and the diagram revealing typical spikes in the valence band. The results of this study suggest thermal emission as the principal mechanism of current passage. The authors thank A. YA. BUL' for discussions with valuable comments and V. I. FEDOROV for making it possible to determine the amount of surface flexure of energy bands. Figures 3; references 8: 5 Russian; 3 Western. [133-2415]

THERMAL QUENCHING OF LUMINESCENCE IN GLASSY CHALCOGENIDE SEMICONDUCTORS

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11,
Nov 79 pp 2246-2248 manuscript received 23 Mar 79

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[Abstract] In a study concerning the nature of electron states in the forbidden band of glassy chalcogenide semiconductors, the temperature dependence of the luminescence quantum yield is examined and found to be determined by nonradiative transitions on recombination centers. This temperature dependence, exponential over the 20-200 K range and heretofore attributed to large-scale fluctuations of internal electric fields, is here interpreted in terms of the relation $\gamma(T) = \frac{P_r}{P_r + P_{nr}(T)}$ (P_r denoting

the probability of almost temperature-independent radiative recombination and P_{nr} denoting the probability of concurrent temperature-dependent non-radiative transition). A nonradiative transition from a metastable state to a ground state occurs by tunneling only at low temperatures, by some thermal excitation with subsequent less tunneling at intermediate temperatures, or by thermal activation without tunneling at high temperatures. An analysis of nonradiative transition, in the quasi-classical approximation, reveals a distinct role of small-scale fluctuations of recombination-center parameters. The results indicate, furthermore, a nonactivational quenching of luminescence in these semiconductors over a rather wide temperature range. The authors thank S. D. BARANOVSKIY, V. A. VASIL'YEV, B. I. SHKLOVSKIY and A. L. EFROS for discussing the results of this study. Figures 1; references 7: 2 Russian; 5 Western.

[133-2415]

USSR

UDC 621.315.592

SUBMILLIMETER PHOTOCONDUCTION IN n-InSb AT 4.2-77 K TEMPERATURES

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2256-2259 manuscript received 27 Apr 79

FILONOVICH, S. R., Moscow State Pedagogical Institute imeni V. I. Lenin

[Abstract] Photoconduction in n-InSb with nearly full compensation is examined over the temperature range from liquid helium (4.2 K) to liquid nitrogen (77 K), in terms of the temperature dependence of power-voltage sensitivity. At the low end of this range photons stimulate hopping photoconduction near the Fermi level along with static conduction. At higher temperatures free electrons facilitate mobility-photoconduction. As the temperature increases over this range, therefore, the power-voltage sensitivity decreases first slowly and then fast. While at 4.2 K the sensitivity is by almost one order of magnitude higher at the $\lambda = 1$ mm wavelength than at the $\lambda = 8$ mm wavelength, at 77 K the sensitivity is almost the same at both wavelengths and reaches 1 V/W. The temperature dependence of the mobility of free electrons, characteristic of highly compensated materials, confirms the contribution of free electrons to photoconduction at higher temperatures due to changes in their mobility caused by electro-magnetic radiation. The author thanks YE. M. GERSHENZON and L. B. LITVAKGORSKAYA for the discussion. Figures 2; references 9:

8 Russian; 1 Western.

[133-2415]

USSR

UDC 621.315.592

STRONG FRANCK-CONDON SHIFT OF A DEEP CENTER IN GaAs <0>

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2270-2272 manuscript received 17 May 79

MALINAUSKAS, R. A., PERVOVA, L. YA. and FISTUL', V. I., State Scientific Research and Planning Institute of the Rare Metals Industry

[Abstract] A study of GaAs crystals containing oxygen was made by simultaneous optical and thermal excitation of impurity centers. The n-GaAs specimens doped with oxygen had an electrical resistivity of $2\Omega \cdot \text{cm}$, a carrier concentration of $6 \cdot 10^{14} \text{ cm}^{-3}$ and a carrier mobility of $5.5 \cdot 10^3 \text{ cm}^2/\text{V.s}$ at 300 K. The photoconduction spectrum at 77 K reveals in the $\hbar\nu > 0.4$ eV range two plateaus caused by photoionization of centers with transition of electrons to the conduction band, corresponding to $E_c - 0.42$ eV and $E_c - 0.7$ eV respectively, and in the $\hbar\nu < 0.4$ eV range of resonance

band with a half-width of 0.060 eV. Hall-effect measurements yield E_c -0.18 eV and E_c -0.42 eV, although no impurity photoconduction center corresponding to E_c -0.18 eV appears in the photoconduction spectrum, which indicates that both readings correspond to the same center with a strong Franck-Condon shift of 0.24 eV. The luminance-current characteristic of impurity photoconduction of $\Delta\lambda = 0.52$ and 0.75 eV indicate, furthermore, that the 0.7 eV level is filled completely and the 0.42 eV level is filled partly. The authors thank E. M. OMEL'YANOVSKIY, YU. YA. TKACH and YE. V. CHENSKIY for the interest and many helpful comments, as well as O. G. STOLYAROV for supplying the specimens. Figures 3; references 7: Western.
[133-2415]

USSR

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THEORY OF THE MAGNETODIODE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 13 No 11, Nov 79 pp 2144-2152 manuscript received 23 Nov 78; finally edited 16 Apr 79

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[Abstract] A further contribution is made to the theory of the magnetodiode by consideration of a rectangular semiconductor slab with hole injection at one end and electron injection at the other, in a transverse external magnetic field. Assuming negligible diffusion processes at the injection contacts, assuming diffusion currents currents to be negligible in comparison with drift currents, and disregarding the intrinsic magnetic field caused by diode currents, the current-voltage characteristics of such a device are calculated from the fundamental two-dimensional equations for electron concentration and electric field distributions in the case of weakly injecting contacts as well as in the cases of weak and strong electric fields respectively. The theoretical current-voltage characteristics and also current-induction characteristics, with the induction either positive or negative, are compared with experimental curves. The fair agreement of results confirms the validity of the drift approximation in the case of long diodes and the high sensitivity of the magnetodiode effect to the rate of surface recombination. Figures 3; references 10: 5 Russian; 5 Western (1 in translation).
[133-2415]

NATURE OF THE CURRENT MAGNETOSENSITIVITY OF 2-COLLECTOR PLANAR MAGNETOTRANSISTORS

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[Abstract] In real 2-collector planar silicon magnetotransistors the current is sensitive not only to the transverse component of magnetic induction, according to the Sula-Shockley effect, but also to its tangential component. Here an experimental study was made in order to determine the relation between the drift component and the diffusion component of magnetosensitivity. Specimens of magnetotransistors were built on KEF-10 base material with a $40 \times 40 \mu\text{m}$ emitter p^+ -region, two $150 \times 50 \mu\text{m}$ collector p^+ -regions, all p-n junctions at a $2.5 \mu\text{m}$ depth, and the distance between both collectors varied from 50 to $150 \mu\text{m}$. The change of collector current was measured as a function of the magnetic induction with the vector of the latter oriented transversely and the relation found to be a linear one. The change of collector current was also measured and found to vary sinusoidally with the orientation angle of the magnetic induction vector rotating 360° . The magnetic induction was varied up to 0.5 T , the emitter current was varied up to 6 mA , the base current was varied up to 10 mA , and the collector-base voltage was held at 30 V . On the basis of the results, planar magnetotransistors have a magnetosensitivity much higher to the tangential component than to the normal component of magnetic induction. Figures 4; references 5: 4 Russian; 1 Western (translated). [133-2415]

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